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Of the
Mensuration,
of
Solids.

Definitions.

- 1 The measure of any solid body is the whole capacity or content of that body when considered, under the triple dimensions of length, breadth and thickness.
- 2 A cube, the side of which is one inch, one foot, or one yard, &c. is called the measuring unit; and the

content or solidity of any figure, is computed by
 the number of these cubes, contained in that figure.
 3. A cube, is a solid contained by six equal square
 sides.

4. A parallelepipedon is a solid contained by six
 quadrilateral planes, every opposite two of which,
 are equal and parallel.

5. A prism is a solid, the ends of which are two equal, parallel, and similar plane figures and its sides parallelograms.

6. A cylinder is a solid described by the revolution of a right angled parallelogram about one of its sides which remains fixed.

7. A pyramid is a solid the sides of which are all triangles meeting at a point at the vertex, and the base any plane figure whatever.

8. A sphere is a solid, described by the revolution of a semicircle, about its diameter, which remains fixed.

9. The centre of a sphere is a point within the figure, every where equally distant from the convex surface of it.

10. The diameter of the sphere is a straight line passing through the centre and terminated both ways by the convex superficies.

11. A circular spheroid, or spindle, is a solid generated by the revolution of a segment of a circle, about its chord, which remains fixed.

12. A spheroid, is a solid, generated by the revolution of a semiellipse, about one of its diameters, which remains fixed.

The spheroid, is called prolate, when the revolution is made about the transverse diameter and oblate, when it is made about the conjugate.

13. Ellipses, parabolas, and hyperbolas, spindles, are generated in the same manner as the circular spindle, the double ordinate of the sections being always fixed, or quiescent.

14. Parabolic, and hyperbolic conoids, are solids, formed by the revolution of a semi-parabola, or semi-hyperbola, about its transverse axis, which is fixed.

15. The segment of a Pyramid, sphere, or any other solid, is a part cut off from the top, by a plane parallel to the base of that figure.
16. A frustum, or trunk is the part that remains at the bottom, after the segment is cut off.
17. The zone of a sphere, is that part which is intercepted, between two parallel planes; and when these planes are equally distant from the centre, it is called the middle zone of the sphere.
18. The height of a solid, is perpendicular being a line drawn from its vertex, to the base or plane on which it is supposed to stand.

Problem 1st

To find the solidity of a cube, the height of one of its sides being given.

Rule.

Multiply the side of the cube, by itself and that product again by the side, and it will give the solidity required.

Examples.

The side A C, or I M, of the cube A, C, I, M, N, R, L, W, is 25.5 what is the solidity.

Here $AC^3 = 25.5^3 = 25.5 \times 25.5 \times 25.5 = 25 \times 650.25 = 16501.375 = \text{content of the cube.}$

The side of a cube is 15 inches: what is the solidity.

Here $15^3 = 15 \times 15 \times 15 = 225 \times 15 = 3375$ inches

And $3375 \div 1728 = 1.11.5 =$ ^{11 in.} cube required.

What is the solidity of a cube, the side of which is 17.5 inches.

Here $17.5^3 = 306.25 \times 17.5 = 5359.375$ inches.

And $5359.375 \div 1728 = 3.104 =$ solidity required.

Problem 2nd

To find the solidity of a parallelopipedon.

Rule.

Multiply the length by the breadth, and that product again, by the depth, or altitude, and it will be the solidity required.

Examples.

Required the solidity of the parallelopipedon
A, B, C, D, E, F, G, H, I, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, the length A, B, of 10 inches is

8 feet, the breadth 7 feet and the depth,
or at the end, 6 $\frac{3}{4}$ feet?

Here $8 \times 6.75 \times 4.5 = 54 \times 4.5 = 243$ = contents req

The length of a parallelopipedon, is 15 feet and
each side of its square base 2 inches, what is
the solidity.

Here $17.5 \times 15 \times 17.5 = 262.5 \times 17.5 = 4593.75$
= solidity required.

What is the solidity of a block of marble, the length
of which is 10 feet, breadth 5 $\frac{3}{4}$, and depth 3 $\frac{1}{2}$ feet

Here $5.75 \times 10 \times 3.5 = 37.50 \times 3.5 = 201.250$ =
solidity required in square feet. —

Problem 3rd

To find the solidity of a prism.
Rule.

Multiply the area of the base, into the perpendicular height, of the prism, and the product will be the solidity.

Examples.

What is the solidity of the triangular prism, A, E, T, M, G, V , the length AE of which, is 10 feet, and either of the equal sides ET, TM , or EM , of one of its equilateral ends, E, M, T , $2\frac{1}{2}$ feet. -

Here $\frac{2.5 + 2.5 + 2.5}{2} = \frac{7.5}{2} = 3.75 = \frac{1}{2}$ sum of the sides.

And $3.75 - 2.5 = 1.25 = \therefore$ differences.

Whence $\sqrt{3.75 \times 1.25 \times 1.25 \times 1.25} = \sqrt{7.32421875}$
 $= 2.7063 =$ area of the base.

And $2.7063 \times 10 = 27.063$ solid feet - solidity req?

What is the solidity of a triangular prism, the length of which is 18 feet, and one side of the equilateral end, $\frac{1}{2}$ foot?

Here $\frac{1.5 + 1.5 + 1.5}{2} = \frac{4.5}{2} = 2.25 = \frac{1}{2}$ sum of the sides.

And $2.25 - 1.5 = .75 = \therefore$ differences.

Whence $\sqrt{3 \times .75 \times .75 \times 2.25} = \sqrt{2.25 \times .75} = \sqrt{94.921875} = 9.742 =$ area of regular base of the prism.

And $9.742 \times 18 = 17.5356$ solid feet - solidity required

Required the solidity of a prism, the base of which
is a hexagon, supposing each of the equal sides, to be
1 foot 4 inches, and the length of the prism, 15 feet.

Here $2.5980762 \times 1.3^2 =$ the number to be multi-

plied by, when the figure is an hexagon $\times 1.3^2 =$

$2.5980762 \times 1.33333 \times 1.33333 =$

$2.5980762 \times 1.777768 = 4.620548129216$

= area of the base.

And 4.620548129216×15 the height
of the figure = $69.278221938240 =$ the
solidity required. -

Problem 4th

To find the convex surface of a cylinder.

Rule.

Multiply the periphery, or circumference, of the
base, by the height of the cylinder, and the product
will be the convex surface required? -

Examples.

What is the convex surface of the right cylinder,
 A, G, C, M : the length of which C, G is 20 feet and
 the diameter of its base C, M , 2 feet.

Here $3.14159 \times 2 = 6.28318 =$ periphery of C, M .
 And $6.28318 \times 20 = 125.6636$ sq. feet = convexity reqd.

What is the convex surface of a right cylinder, the
 diameter of the base of which is 30 inches, and
 the length 60 inches.

Here $3.14159 \times 30 = 94.24838 =$ periphery of base.
 And $94.24838 \times 60 = 5654.9028 =$ convexity required.

Required the convex superficies of a right cylinder,
the circumference of which is 8 feet 4 inches, and its
length $1\frac{1}{4}$ feet.

Here 8.3333 = circumference of the base.
And $8.3333 \times 1\frac{1}{4} = 116.6666$ & 19 feet = con-
vexity required.

Problem 5th

To find the solidity of a cylinder.

Rule.

Multiply the area of the base, by the perpendic-
ular height of the cylinder, and the product
will be the solidity.

Examples.

What is the solidity of the cylinder E, G, H, M ,
the diameter of the base E, M , of which is 30
inches, and the height M, G , 50 inches.

Here $7054 \times 30^2 = 7054 \times 900 = 706.36 =$
area of the base C.M.

And $706.86 \times 50 = 35343$ cubic inches; or $\frac{35343}{1728}$
 $= 20.4531$ solid feet, the answer required.

What is the solidity of a cylinder, the height of
which is 5 feet, and the diameter of the end
2 feet.

Here $7054 \times 2^2 = 7054 \times 4 = 31416 =$ area of base
And $31416 \times 5 = 157080$ solid feet = the
solidity.

What is the solidity of a cylinder, the height of which
is 20 feet, and the circumference of the base, 20 feet also.
Here $22 : 7 :: 20 : 6.37 =$ diameter. And 7054
 $\times 6.37^2 = 405809 \times 7054 = 318.7 =$ area of base
Also $318.7 \times 20 = 6374.40 =$ solid feet of
cylinder required.

The circumference of the base of an oblique cylinder,
is 20 ft, and the perpendicular height, 19.318.
what is the solidity?

Here $22:7::20:6.36$ = diameter And 6.36^2
 $\times 7854 = 4045 \times 7854 = 318$ = area of base
Also $19.318 \times 318 = 6143.124$ = solidity reqd.

Problem 6th

To find the convex surface of a right cone.
Rule.

Multiply the circumference of the base, by the slant
height, or the length of the side of the cone, and
it will be the surface required.

Examples.

The diameter of the base AB is 3 feet, and
the slant height AM , is 15 feet, required the
convex surface of the cone AMT .

Here $3.1416 \times 3 = 9.4248 = \text{circumference of the base 4 PM.}$

And $\frac{9.4248 \times 15}{2} = \frac{141.372}{2} = 70.686 \text{ square feet} = \text{convex surface required.}$

The diameter of a right cone is 4.5 feet, and the slant height, 20 feet; required the convex surface.

Here $3.1416 \times 4.5 = 14.1372 = \text{circumference of the base.}$

And $\frac{14.1372 \times 20}{2} = \frac{282.744}{2} = 141.372 = \text{convex surface required in square feet}$

The circumference of the base is 10.75, and the slant height 18.25; what is the convex surface?

$$\text{Here } \frac{10.75 \times 18.25}{2} = \frac{106.875}{2} = 53.4375$$

53.4375 = convex surface required.

Problem 7th.

To find the convex surface of the frustum of a cone.
Rule.

Multiplying the sum of the perimeters of the two ends, by the slant height of the frustum, and half the product, will be the surface required.

Examples.

In the frustum A, E, K, M is the circumference of the two ends, N, K and O, M are 22.5 and 15.75 respectively, and the slant height N, K, M is 26 what is the convex surface.

Here $\frac{22.5 + 15.75}{2} \times 26 = 26 \times 38.25 \div 2 = 994.5$
 $= 997.25 = \text{convex surface required}$

What is the convex surface, of the frustum of a right cone, the circumference of the greater end, being 30 feet, that of the lesser end, 10 feet and the entire length of the slant side, 20 feet.

Here $\frac{30 + 10}{2} \times 20 = \frac{40 \times 20}{2} = \frac{800}{2} = 400$
 square feet = convexity required.

What is the surface of a frustum if a segment, be cut off 6 feet slant from a cone of 30 feet slant the base being 10 feet in circumference.

Here $\frac{30 \text{ circum. of base } 10}{2} = \frac{30 \times 10}{2} = \frac{300}{2} = 150 = \text{convex surface of the whole cone}$

And $150 - \text{the piece cut off} = 150 - 6 = 144 =$
 frustum required.

What is the convex surface of the frustum of a right
cone, the diameter of the ends, being 8, and 4 feet, and
the length of the slant side, 20 feet.

$$\text{Here } 3.1416 \times 8 + 3.1416 \times 4 = 25.1328 +$$

$$12.5664 = 37.6992 =$$

$$\text{And } 37.6992 \times 20 = 37.6992 \times 10 =$$

$$376.992 = \text{convex surface required.}$$

Problemth

To find the solidity of a cone or pyramid.

Rule.

Multiply the area of the base, by $\frac{1}{3}$ of the perpen-
dicular height, of the solid, and the product will
be the solidity.

Examples.

Required the solidity of the cone E, W, R, the
diameter E, W, which, is 20 and its perpendicular
height E, R 24.

Here, $7054 \times 20^2 = 7054 \times 400 = 314.16 = \text{area}$
of the base $E W$

And $314.16 \times \frac{20}{3} = 314.16 \times 8 = 2513.28 = \text{solid}$
ly required

Required the solidity of the Hexagonal pyra-
mid E, P, R, W , each of its equal sides, being 40
at the base and the perpendicular height $R W 60$.
Here 2.598076 (multiplier when the side is 1) $\times 40^2$
 $= 2.598076 \times 1600 = 4156.9216 = \text{area of the base}$
And $4156.9216 \times \frac{60}{3} = 4156.9216 \times 20 =$
83138.432 solid *ly* required.

Required the solidity of a triangular pyramid,
the height of which is 30, and each side of the base 3.

Here 0.433013 (mul. tripl. when the side is 1)
 $\times 3^3 = 433013 \times 9 = 3897117 = \text{area of the base}$
And $3897117 \times \frac{30}{3} = 3897117 \times 10 = 38971170$
 $= \text{solidity required.}$

Required the solidity of a square pyramid, each
side of the base of which is 30, and the perpendicular
height, 20.

Here 1 (mul. tripl. when the side is 1) $\times 30^2 = 1 \times$
 $900 = 900 = \text{area of the base.}$
And $900 \times \frac{20}{3} = 900 \times 6.6 = 6000 = \text{solid. reqd.}$

What is the solidity of a cone the diameter of the
base of which is 18 inches, and its altitude,
15 feet.

Here $7054 \times 18^2 = 7054 \times 324 = 2544696$
inches.

And $2544696 \times 8 = 17632768 \times 5 =$
 $876630 = \text{solidity}.$ -

If the circumference of the base of a cone, be 40
feet, and the height 50 feet, what is the solid-
ity?

Here $22:7::40:127.20 \times 20 = 127.20000$
= area of the base.

And $127.20000 \times \frac{50}{3} = 127.2000 \times$
 $16.6 = 2122.3333 = \text{solidity required}.$ -

What is the content of a pentangular pyramid,
its height being 12, and each of its base, 2 feet.
Here $1720477 \times 2 = 6881900 = \text{area required}.$
And $6881900 \times \frac{12}{3} = 6881900 \times \frac{12}{3} = 2752763$
= solidity required. -

Problem 9th

To find the solidity of the frustum of a cone or pyramid.
Rule.

1. For the frustum of a cone, the diameters of the two ends, and the height being given.

Divide the difference of the cubes of the diameters of the two ends, by the difference of the diameters, and this quotient being multiplied by .7854, and again by $\frac{1}{3}$ of the height, will give the solidity.

2. For the frustum of a pyramid, the sides, and height, being given.

Add the areas of the two ends, of the frustum, add the square root of their product, and this sum being multiplied, by $\frac{1}{3}$ of the height, will give the solidity.

Examples.

What is the solidity of the frustum of the

cone CEM , the diameters of the greater end of which EM is 5 feet, that of the lesser end CN 3 feet and the perpendicular height, $7\frac{1}{2}$ feet.

Here $\frac{5^3 - 3^3}{5 - 3} \times 7\frac{1}{2} \times \frac{2}{3} = \frac{125 - 27}{2} \times 7\frac{1}{2} \times 3$
 $= 90 \times 2.3562 = 49 \times 2.3562 = 115.4538$
 solid feet = content of the frustum.

What is the solidity of the frustum CEM , of an hexagonal pyramid, the side CN of the greater end of which, is 4 feet, and the side EM of the lesser end 3 feet, and the height, $7\frac{1}{2}$ feet?

Here 2.5980767 (tabular) $\times 3^2 = 2.598076 \times 9$
 $= 23.382684$ area of the polygon $E M$.
 And 2.598076 (tabular) $\times 4^2 = 2.598076 \times 16$
 $= 41.569216$ area of the polygon $E N$.
 Wherefore $41.569216 \times 2.598076 = 10771.99984$
 $= 31.176911$.
 And $23.382684 + 41.569216 + 31.176911 \times \frac{2}{3}$
 $= 96420011 \times 3 = 288386433$ feet solid measure.

What is the solidity of the frustum of a cone,
 the diameter of the greater end, being 4 feet, that
 of the lesser end, 2 feet, and the altitude, 9 feet
 Here $\frac{4^3 - 2^3}{4 - 2} = \frac{64 - 8}{2} = \frac{56}{2} = 28$. And 28×7854
 $\times \frac{2}{3} = 219912 \times 3 = 659736$ = content of the frustum

What is the solidity of the frustum of a cone,
the circumference of the greater end being 40,
that of the less 20, and the length or height 50.

Here $22:7::40:13$ = diameter of g. end. And

$22:7::20:6.4$ = diameter of lesser end.

$$\text{Also } \frac{13^3 - 6.4^3}{13 - 6.4} = \frac{2197 - 262.704}{6.6} = \frac{1934.296}{6.6} = 293.06.$$

$$\text{Thence } 293.06 \times 7054 \times \frac{50}{3} = 2307693248 \\ \times 16.6 = 3730810678 = \text{solidity required.}$$

What is the solidity of the frustum of a square
pyramid, one side of the greater end, being
18 inches, that of the less end, 15 inches, and the
height 60 inches.

$$\text{Here } (15^3 \times 18^3 \div 15^3 + 18^3 \times) \frac{60}{3} = (\sqrt{225 \times 324} \\ + 225 + 324) \times \frac{60}{3} = (72900 + 549) \times 20 = (270 + \\ 549) \times 20 = 819 \times 20 = 16380 \text{ inches} = \\ \text{solidity required}$$

What is the solidity of the frustum of an hexagonal pyramid, the side of the greater end of which is 3 feet, that of the lesser end, 2 feet and the length 12 feet. -

$$\text{Here } 2.598076 \times 3^2 = 2.598076 \times 9 = 23.382684 = \text{area of the polygon.}$$

$$\text{And } 2.598076 \times 2^2 = 2.598076 \times 4 = 10.392304 = \text{area of the small end.}$$

$$\text{Whence } \sqrt{23.382684 \times 10.392304} = \sqrt{242.993960463936} = 15.588263.$$

$$\text{And } (23.382684 + 10.392304 + 15.588263) \times \frac{12}{3} = \cancel{297.453004} \times 4 = 49.3632518 \times 4 = 197.453004 = \text{solidity required of the frustum.}$$

(1) Problem 10th

To find the solidity of a cuneus, or wedge.

Rule.

Multiply the sum of twice the length of the base, and the length of the edge, by the product of the height of the wedge, and the breadth of the base, and 6 of the last product will be the solidity.

Examples.

How many solid feet are there in the wedge,

AC, CB, BA, MA, MC , the base AC , which is 5.5 ^{in.}

long and the breadth CB 9. the length of the edge BA , 12 ^{in.}

and the perpendicular height MP 2 feet 4 inches.

$$\text{Here } \frac{(64 \times 2 + 42) \times 20 \times 9}{6} = \frac{(128 + 42) 20 \times 9}{6} =$$

$$\frac{170 \times 20 \times 9}{6} = \frac{170 \times 252}{6} = \frac{42840}{6} = 7140$$

Solid inches.

$$\text{And } 7140 \div 1728 = 4.127 \text{ solid feet} = \text{solid required.}$$

The length, and breadth, of the base of a wedge are 35 and 15 inches, and the length of the edge is 55 inches: what is the solidity, supposing the perpendicular height to be 17.14508 inches

$$\text{Here } \frac{(35 \times 2 + 55) \times 15 \times 17.14508}{6} =$$

$$\frac{125 \times 15 \times 17.14508}{6} = \frac{(70 + 55) \times 15 \times 17.14508}{6}$$

$$= \frac{125 \times 257.17620}{6} = \frac{32147.02500}{6} =$$

$$5357.83750 \text{ solid inches} = \text{solidity of the wedge.}$$

$$\text{And } 5357.83750 \div 1728 = 3.1006 =$$

solidity required in feet. -

Problem 11th

To find the solidity of a Trismoid.
Rule.

To the sum of the areas of the two ends, add four times the area of a section, parallel to and equally distant from, both ends, and this last sum, multiplied by $\frac{1}{6}$ of the height will give the solidity.

Note. The length of the middle rectangle is equal to half the sum of the lengths of the rectangles of the two ends, and its breadth equal to half the sum of the breadths of those rectangles.

Examples.

What is the solidity of a rectangular trismoid, the length and breadth of one end, being 14, and 12 inches, and the corresponding sides of the other 6, and 8 inches; and the perpendicular, $30\frac{1}{2}$ feet.

Here $14 \times 12 + 6 \times 4 = 168 + 24 = 192 = \text{sum of}$

the areas of the two ends

Also $\frac{14+6}{2} = \frac{20}{2} = 10 = \text{width of the middle rectangle}$

And $\frac{12+4}{2} = \frac{16}{2} = 8 = \text{breadth of the middle rectangle}$

Whence $10 \times 8 \times 4 = 80 \times 4 = 320 = 4 \text{ times the area of the middle rectangle.}$

$(320 + 192) \times \frac{366}{6} = 512 \times 61 = 31232 \text{ solid inches.}$

And $31232 \div 1728 = 18.074 \text{ solid feet the content of the prismoid.}$

What is the solid content of a prismoid, the greater end of which measures 12 inches by 8, the less end 8 by 6 and the length or height 60 inches.

$$\begin{aligned}
 & \text{Here } \left\{ (12 \times 0 + 0 \times 6) + \frac{12 + 0 \times 0 + 6 \times 4}{2} + \frac{60}{6} \right\} \\
 & = \{ 96 + 40 \} + \frac{20}{2} \times \frac{14 \times 4}{2} \left\{ = 144 + 10 \times 7 \times 4 \right\} 10 \\
 & = \frac{144 + 70 \times 4}{1720} \times 10 = \frac{144 + 200 \times 10}{1720} = \frac{424 \times 10}{1720} \\
 & = 4240 \text{ inches} = 253 \text{ feet} \text{ solidity requir.}
 \end{aligned}$$

That is the capacity of a coal-wagon, the
 inside dimensions of which are as follows: at the
 top the length is 81/2 and breadth 55 inches;
 at the bottom, the length is 41, and the breadth
 29 inches; and the perpendicular depth is 47/4 in.
 Here $81.5 \times 55 + 29.5 \times 41 = 1209.5 + 4482.5$
 $= 5792$ - sum of the areas of the two ends.
 Also $\frac{81.5 + 41}{2} = \frac{122.5}{2} = 61.25$ - length of middle rect.
 And $\frac{29.5 + 55}{2} = \frac{84.5}{2} = 42.25$ - breadth of middle rect.
 Whence $61.25 \times 42.25 \times 4 = 2587.8425 \times 4 = 10351.25$
 $= 4$ times the area of middle rectangle.
 And $10351.25 \times 0 + 5792 \times \frac{47/4}{6} = 16043.25 \times 7.875$
 $= 126340.59375$ cubic inches: 1 chaldron of coals nearly.

Problem 12th

To find the convex surface of a sphere, that is regular.
Rule.

Multiply the diameter of the sphere, by its circumference and the product will be the convex superficies required.

Note. The curve surface of any zone, or segment, will also be found, by multiplying its height, by the whole circumference, of the sphere.

Examples.

What is the convex superficies, of a globe E, G, M , the diameter E, G of which is 17 inches

Here 3. $12159 \times 17 \times 17 = 5320703 \times 17 = 907919$
51 square inches.

And $90791951 \div 144 = 630499$ square feet.
the answer

What is the convex superficies of a sphere, the
diameter of which is 13 feet, and the circum-
ference is 1888 feet.

Here 4. $1888 \times 13 = 55850$. = superficies requir^d.

If the diameter or axis of the earth, be $7957 \frac{3}{4}$
miles; what is the whole surface, supposing it
to be a perfect sphere.

Here $7957.5 \times 314160 \times 314160 =$
 $2500000674 \times 314160 =$ the surface of the
whole earth = 198944206352350 square
miles.

The diameter of a sphere, is 25 inches; what
is the convex superficies, of that segment of it,
the height of which is $4\frac{1}{2}$ inches.

Here $31416 \times 21 \times 4.5 = 659736 \times 4.5 =$
 $29680120 =$ ans^r required in inches.

What is the convex surface of a spherical
zone, the breadth of which is 4 inches, and
the diameter of the sphere, which was cut
25 inches.

Here $3.1416 \times 25 \times 4 = 78.54 \times 4 = 314.16$
inches. -

Problem 13th

To find the solidity of a sphere or globe.

Rule

Multiply the cube of the diameter, by 5236,
and the product will be the solidity.

Examples

What is the sphere A, B, C, the diameter of
which is 17 inches.

Here $17^3 \times 5236 = 17 \times 17 \times 17 \times 5236 = 209$
 $\times 17 \times 5236 = 4913 \times 5236 = 2572.4460$ in.

And $2572.4460 \div 1728 = 1.48868 =$ the
ans. in solid feet.

What is the solidity of a sphere, the diameter
of which is $1\frac{1}{3}$ feet or 16 inches

$$\begin{aligned} \text{Here } 16^3 \times 5236 &= 16 \times 16 \times 16 \times 5236 = 29^5 6 \\ &\times 16 \times 5236 = 4096 \times 5236 = 2144 \cdot 6656 \text{ in} \\ \text{And } 2144 \cdot 6656 &\div 1728 = 1 \cdot 2411 = \text{ans.} \end{aligned}$$

What is the solidity of the Earth, supposing it
to be perfectly spherical, and it diameter $7957\frac{1}{2}$
miles.

$$\begin{aligned} \text{Here } 7957 \cdot 75^3 \times 5236 &= 7957 \cdot 75 \times 7957 \cdot 75 \times \\ 7957 \cdot 75 \times 5236 &= 63325785 \cdot 0625 \times 7957 \cdot 75 = \\ 63325785 \cdot 0625 \times 6236 &= 503930766081 \cdot \\ 109375 \times 6236 \text{ given multiplier in rule given} &= \\ 263858149120 \cdot 0689687500 &= \text{solidity required.} \end{aligned}$$

Problem 14th

To find the solidity of a segment of a sphere.
Rule.

To three times the square of the radius of its base, add the square of its height; and this sum multiplied by the height, and the product again by 5236, will give the solidity.

Examples.

The radius EC , of the base of the segment ECM , is 7 inches, and the height MG , 4 inches: what is the solidity.

Here $17^2 \times (5236 \times 3 + 4^2) \times 4 = 49 \times 3 \times 4^2$
 $\times 4 \times 5236 = 147 + 4^2) \times 4 \times 5236 = 163 \times 4 \times$
 $5236 = 341.3872$ solid inches.

What is the solidity of the segment of a sphere, the diameter of the base of which is 20 and its height 9.

$$\begin{aligned} \text{Here } (10^2 \times 3 + 9^2) \times 9 \times .5236 &= (100 \times 3 + 81) \\ \times 9 \times .5236 &= (300 + 81) 9 \times .5236 = 381 \times 9 \times \\ .5236 &= 1795.4244 = \text{Ans.} \end{aligned}$$

What is the content of the spherical segment, the height of which is 4 inches, and the radius of its base 8?

$$\begin{aligned} \text{Here } (8^2 \times 3 + 4^2) \times 4 \times .5236 &= (64 \times 3 + 16) \times 4 \\ \times .5236 &= (192 + 16) \times 4 \times .5236 = 208 \times 4 \times .5236 \\ &= 832 \times .5236 = 435.0352 = \text{ans.} \end{aligned}$$

What is the solidity of a spherical segment, the diameter of its base being 17.23368, and its height 4.5,

$$\begin{aligned} \text{Here } (.861684^2 \times 3 + 4.5^2) \times 4.5 \times .5236 &= 2227498 \times 4.5^2 \times 4.5 \\ \times .5236 &= 1093 \times .5236 = 572.2948 = \text{ans. required.} \end{aligned}$$

Problem 16th

To find the solidity of a frustum of a cone of a sphere
Rule.

To the sum of the squares of the radii, of the two
ends, add $\frac{1}{3}$ of the square of their distance, or the
breadth of the zone, and this sum multiplied
by the said breadth, and the product again by
 1.5708 , will give the solidity.

Examples

What is the solid content of the zone A, E, G, M
The greater diameter of which A, E, is 20 inches,
The less diameter, G, M, 15 inches and the dis-
tance T, V, of the two ends 10 inches.

$$\text{Here } (10^2 + 7.5^2 + \frac{10^2}{3}) \times 10 \times 1.5708 = (100 + 56.25 + 33.33) \times 10 \times 1.5708 = 189.58 \times 10 \times 1.5708 = 1895.8 \times 1.5708 = 2977.92264 = \text{sol.}$$

What is the solid content of a zone, the greater diameter of which is 24 inches, the less diameter 20 inches, and the distance of the ends, 4 inches.

$$\text{Here } (12^2 + 10^2 + \frac{4^2}{3}) \times 4 \times 1.5708 = (144 + 100 + 5.33) \times 4 \times 1.5708 = 249.3 \times 4 \times 1.5708 = 997.33 \times 1.5708 = 1566.507166 = \text{sol. required.}$$

Required the solidity of the middle zone, of a sphere, the top and bottom diameters of which, are each 3 feet, and the breadth of the zone 4 feet. -

$$\text{Here } (1.5^2 + 1.5^2 + \frac{4^2}{3}) \times 4 \times 1.5708 = (2.25 + 2.25 + 5.33) \times 4 \times 1.5708 = 9.83 \times 4 \times 1.5708 = 39.32 \times 1.5708 = 61.763.850 = \text{solidity required.}$$

Problem 17th

To find the surface of a circular spindle, the length and breadth, or middle diameter, being given.

10

Rule.

1. To the square of half the length of the spindle, or longest diameter, add the square of half the middle diameter, and this sum divided by the middle diameter, will give the radius of the circle.
2. Take half the middle diameter, from the radius of the circle, and it will give the central distance.
3. Find the length of the revolving arc, by problem the 10th. Mens. ^{of} Superficies.
4. From the product of the longest diameter, and the radius of the revolving arc, subtract the product of the said arc, and the central distance, and this remainder multiplied by 6.2832, will give the surface required.

Examples.

What is the superficial content of the circular spindle AEG , the length AE which is, 48 and the middle diameter, 36.

$$\text{Here } (24^2 + 18^2) \div 36 = 576 + 324 \div 36 = 900 = \frac{100}{4} = 25 = W = \text{radius of the circle } ATE$$

Therefore $25 - 18 = 7 = \text{central distance. eg.}$

$$\text{And } \frac{2 \times 18}{3} \div \left(50 - \frac{41 \times 18}{50} \right) = 12 \div 50 - 14.76 = 12 \div 35.24 = 34052.$$

$$\text{Hence } (1 + 34052) \times 48 = 1.34052 \times 48 = 64.34496 = \text{length of the arc } ATE.$$

$$\begin{aligned} \text{And } (48 \times 25 - 64.34496 \times 7) \times 6.2832 &= (1200 - 450.41472) \times 6.2832 = 749.58528 \times 6.2832 \\ &= 4709.794231296 = \text{superficies required.} \end{aligned}$$

What is the superficial content of a circular spindle, the length of which is 48, and its middle diameter, 30.

$$\text{Here } (24^2 + 15^2) \div 30 = 376 + 225 \div 30 = \frac{601}{30} =$$

23.7 = radius of the circle

Therefore $23.7 - 15 = 8.7 = \text{central distance}$

$$\text{And } \frac{2 \times 15}{3} \div \left(\frac{41 \times 15}{47.4 - 50} \right) = 10 \div 351 = 2849 =$$

$\frac{2}{3}$ of 101 $\div \frac{41}{50}$ of diameter of circle.

$$\text{Also } (1 + 2849) \times 48 = 1.2849 \times 48 =$$

62 nearly = length of the arc

$$\text{Where } (23.7 \times 48 - 62 \times 8.7) \times 6.2832 =$$

$$1137.6 - 540 \times 6.2832 = 795 \times 6.2832$$

$= 3750 = \text{ans}^r$ required of the circular spindle. -

Problem 10th

To find the solidity of a circular spindle, the length, and middle diameter being given.

Rules.

1. Find the area of the generating circular segment, by problem the 13th, and the radius and central distance as in the last problem.
2. From $\frac{2}{3}$ of the cube of half the length of the spindle, subtract the product of the central distance, and half the area of the generating segment and this remainder multiplied by 12.5664, will give the solidity.

Examples.

1. The longest diameter AC , of the circular spindle ACB , is 48, and the middle diameter BC , 36: what is the solidity of the spindle.
Here $\frac{48 \times 7}{2} - 24 \times 7.7$ being the central distance as in the last prob. = 168 = area of the triangle ACB

And 32.17248 ($\frac{1}{2}$ length of the arc AMB by
 last prob.) $\times 25$ (radius by same prob.) = 804.312 =
 area of the sector AMC .

Also $804.312 - 160 = 644.312$ = area of the seg-
 ment AMC .

And $(\frac{24^3}{3} - \frac{644.312}{2} \times 7) \times 12.5664 = \frac{13824}{3}$
 $- 318.156 \times 7) \times 12.5664 = (4608 - 2227.092$
 $\times 12.5664 = 2380.908 \times 12.5664 = 29919.$
 5422912 = solidity required

If the length of a circular spindle be 40, and its
 middle diameter 30: what is its solidity?

Here $\frac{26 \times 15^2}{15} = 41.66$ And $15 \times \frac{2}{3} = 10$ And $15 \times \frac{2}{3} = 10$

$\frac{41}{50} \times 15 = 12.3 = 41.6$ And $3405 + 1 \times 40$

$= 53.62 = \text{length of the arc. And } \frac{41.66}{2} \times \frac{53.62}{2} =$

$2083 \times 26.01 = 55.84523.$

Again $\frac{20.83 + 15}{2} \times 40 = 23.32 \times 1066$ And

$20.83 + 15 = 35.83 = \text{central distance.}$

Consequently $\frac{40}{20} \div 3 = \frac{0000}{3} = 2666.$

And $\frac{55.84523 - 116.66}{2} \times 5.83 = 22069615 \times 5.83$

$= 1346.2475543.$

Thence $2666.66 - 1346.2475543 \times 12.5664 =$

$1689291473029344 = \text{ans. required.}$

Problem 19th

To find the solidity of the middle frustum of a circular spindle, the length of the frustum, the middle diameter, and that of either of the arcs, being given of either of the ends.

Rule.

1. Divide the square of half the length of the frustum, by half the difference of the middle diameter, and that of either of the two ends; and half this quotient added to $\frac{1}{2}$ of the said difference, will give the radius of the circle.
2. Find the central distance, and the revolving area, as in the last problem.
3. From the square of the radius, take the square of the central distance, and the square root of the remainder, will give half the length of the spindle.
4. From the square of $\frac{1}{2}$ the length of the spindle, take $\frac{1}{3}$ of the square of $\frac{1}{2}$ the length of the frustum, and multiply the remainder into the said half length.
5. From this product take that of the generating area, and central distance, and the remainder multiplied by 6.2832, will give the content of the frustum.

Examples.

What is the solidity of the frustum W, M, N, G
The middle diameter mn , which is, 36, the di-
ameter WG , or Mn , 40 and the length ac , 50.

$$\text{Here } \frac{1}{2} \times (20^2 - \frac{36-16}{2}) \times \frac{36-16}{4} = \frac{1}{2} \times (400 - 101) \\ + 5 = \frac{1}{2} \times 40 + 5 = 20 + 5 = 25 = \text{radius of the circle.}$$

$$\text{Consequently } 25 - \frac{1}{2}mn = 25 - 18 = 7 = \text{central distance.} \\ \text{And } \frac{16}{50} = \frac{1}{5} = .2 = \text{tab.versed sine; and } 111823 = \\ \text{tab. segment.}$$

$$\text{And } 279.5573 = (111825 \times 50^2) + 320 = 599.5573 = \\ \text{generating area } WnMn.$$

$$\text{Again } \sqrt{(25^2 - 7^2)} = \sqrt{(625 - 49)} = \sqrt{576} = 24 = \\ \frac{1}{2} \text{ length of the spindle.}$$

$$\text{And } (24^2 - \frac{20^2}{3} \times 20 - 4196.9 \times 6.2832 - 576 - 133.3) \times 20 - 4196.9025 \times 6.2832 = 18053.334 - 4196.9025 \times 6.2832 - 4656.4315 \times 6.2832 = 29257.2904 \text{ solidity required.}$$

The middle diameter of the frustum of a circular spindle is, 32 The diameter at the end, 24 and the length 40 - what is the solidity?

$$\text{Here } \frac{1}{2} \times (20^2 \div \frac{32-24}{2}) + \frac{32-24}{4} = \frac{1}{2} \times (400 \div 4) + 2 + \frac{4}{4} = 50 + 1 = 51 = \text{radius.}$$

$$\text{And } 51 - 32 \div 2 = 51 - 16 = 35 = \text{central distance.}$$

$$\text{Also } 16 \div 102 = \text{diameter} = 156 \therefore \text{Tabularversed sine next number } 078194 \times 102^2 = 078194 \times 20604 = 1611109176 = \text{area of the segment.}$$

$$\text{And } 51^2 - 35^2 = \sqrt{2601 - 1225} = \sqrt{1376} = 37.1 = \frac{1}{2} \text{ the length of the spindle.}$$

$$\text{Also } 37.1^2 - \frac{20^2}{3} \times 37.1 = 1376.41 - \frac{400}{3} \times 37.1 = 1376.41 - 1383 \times 37.1 = 4500617. -$$

Again $45006.97 - 3638.882116 = 1611109.76$
 $\times 35$ or central distance $= 5638.882116$
 And 5638.882116×35 - from $45006.97 \times$
 $6.2832 = 39360.882116 \times 6.2832 =$
 $24735.756979264.88 = \text{ans.}^r$ required of the
 frustum.

Problem 20.th

To find the solid of a spheroid that is regular.

Rule.

Multiply the square of the revolving axis, by
 the fixed axis, and this product again by .5236,
 and it will give the solid required.

Where, note, that .5236 is $\frac{1}{2}$ of 3.14159.

Examples.

In the prolate spheroid AE, V, M , the transverse or
 fixed axis EM is 9 and the conjugate or revolving
 axis AA is 70: what is the solidity.

Here $KA^2 \times 6^3 m \times 5236 = 70^2 \times 90 \times 5236 =$
 $4900 \times 90 \times 5236 = 441000 \times 5236 = 230907.6 =$
 solidity required.

What is the solidity of a prolate spheroid, the
 fixed axis of which is 100, and the revolving axis 60?
 Here $60^2 \times 100 \times 5236 = 3600 \times 100 \times 5236 = 360000.$
 $\times 5236 = 188496 = \text{solidity required}$

What is the solidity of an oblate spheroid,
 the fixed axis of which is 60 and the revolving
 axis 100.

Here $100^2 \times 60 \times 5236 = 10000 \times 60 \times 5236 =$
 $600000. \times 5236 = 314160. = \text{ans}^r \text{ required?}$

Problem 21st

To find the content of the middle frustum of a spheroid, its length the middle diameter, and the distance of the two ends being given.

Case 1st

When the ends are circular, or parallel to the revolving axis

Rule.

To twice the square of the middle diameter, add the square of the diameters of either of the ends and this sum, multiplied by the length of the frustum, and the product again by .2618, will give the solidity.

Where note that .2618 = $\frac{1}{12}$ of 3.14159.

Examples.

In the middle frustum of a spheroid P, T, A, N , the middle diameter EO is 50 inches and

that of either of the ends of T , or A is 40 inches,
and A length of m , 10 inches. what is the so-
lidity

$$\begin{aligned} & \text{Here } (50^2 \times 2 + 40^2) \times 10 \times 2618 = 2500 \times 2 + \\ & 1600 \times 10 \times 2618 = (5000 + 1600) \times 10 \times 2618 \\ & = 6600 \times 10 \times 2618 = 110000 \times 2618 = \\ & 311018400 = \text{solidity required.} \end{aligned}$$

What is the solidity of the middle part of a prolate
spheroid, the middle diameter, being 60, that of either
of the two ends 36, and the distance of the ends 80.

$$\begin{aligned} & \text{Here } (60^2 \times 2 + 36^2) \times 80 \times 2618 = (3600 \times 2 + 1296) \\ & \times 80 \times 2618 = (7200 + 1296) \times 80 \times 2618 = 8496 \times \\ & 80 \times 2618 = 679680 \times 2618 = 177940224 = \\ & \text{solidity required.} \end{aligned}$$

What is the solidity of the middle frustum of an oblate spheroid, the middle diameter being 100, that of either of the ends 80, and the distance of the ends 36.

$$\begin{aligned} \text{Then } 100^2 \times 80^2 \times 36 \times 2618 &= 20000 \times 6400 \times 36 \\ &\times 2618 = 262400 \times 36 \times 2618 = 950400 \times 2618 \\ &2488147200 = \text{ans.}^{\text{r}} \text{ required.} \end{aligned}$$

Case 2nd

When the ends are elliptical or perpendicular to the revolving axis

Rule.

1. Multiply twice the transverse diameter of the middle section, by its conjugate diameter, and to this product add the product of the transverse and conjugate diameters of either of the ends.
2. Multiply the sum thus found, by the distance of the ends, and the product by 2618 it will give the solidity requ^d.

Examples.

1. In the middle frustum THC , MP , & Q , is an oblate spheroid, the diameters of the middle section A & R , are 50×30 , those of the end TH MP , 40 and 24 , and its height AC , 18 ; what is the solidity?

Here, $(50 \times 2 \times 30 + 40 \times 24) \times 18 \times .2618 = (3000 + 960) \times 18 \times .2618 = 3960 \times 18 \times .2618 = 71280 \times .2618 = 18661.104 = \text{solidity required.}$

In the middle frustum of a prolate spheroid, the diameters of the middle section are 100 and 60 , those of the end 80 and 48 , and the length 36 , what is the solidity.

Here $\frac{60 \times 2 \times 100 + 80 \times 48}{3} = 1200 + 3840$ and =
 15040

Also $15040 \times 36 \times 2618 = 570240 \times 2618 =$
 $1492080320 = \text{solidity required}$

In the middle frustum of a double spheroid
 the diameters of the middle section are 100 and
 60, those of the end 60 and 36; and the length 80,
 what is the solidity of the frustum.

Here $\frac{100 \times 2 \times 60 + 36 \times 60}{3} = 1200 + 2160$
 $= 14160$

And $14160 \times 80 \times 2618 = 1132800 \times 2618 =$
 $2965670400 = \text{solidity required.}$

Problem 22nd

To find the solidity of the segment of a spheroid.
Case 1st -

When the case is parallel to the revolving axis.

Rule.

1. Divide the square of the revolving axis, by the square of the fixed axis, and multiply the quotient, by the difference between three times the fixed axis, and twice the height of the segment.
2. Multiply the product thus found, by the square of the height of the segment, and this product again by .5236, and it will give the solidity required.

Examples.

In the prolate spheroid, A, P, C, N, the transverse axis A Q is 100 and the conjugate T C, 60, and the height G M, of the segment G M, is 10 what is the solidity.

$$\text{Here } \frac{60^2}{100^2} \times (300 - 20) \times 10^2 \times .5236 = .36 \times 280 \times 10^2$$

$$\times .5236 = 100.80 \times 100 \times .5236 = 10080 \times .5236 =$$

$$5277.888 - \text{solidity required.}$$

The axes of a prolate spheroid are 50 and 30: what
 is the solidity of that segment, the height of which is
 5, and its base perpendicular to the fixed axis.

$$\text{Here } \frac{30^2}{50^2} \times 150 - 10 \text{ for } 50 \times 3 - 10^2 \times 5^2 \times .5236 =$$

$$.36 \times 140 \times 25 \times .5236 = 50.40 \times 25 \times .5236 = 1260$$

$$\times .5236 = 669.7.36 = \text{ans. required.}$$

The diameters of an oblate spheroid, 100 and 60:
 what is the solidity of that segment, the height of
 which is 3, and its base perpendicular to the fixed
 axis, or conjugate.

$$\text{Here } \frac{100^2}{60^2} \times 60 \times 3 - 5 \times 2 \times 12^2 \times .5236 = (2.77$$

$$+ 180 - 24) \times 144 \times .5236 = 2.77 \times 136 \times 144 \times$$

$$.5236 = 432.46 \times 144 \times .5236 = 62441.92 \times$$

$$.5236 = 32694.589312 = \text{ans. required.}$$

Case 2nd.

When the base is perpendicular to the revolving axis.

Rule.

1. Divide the fixed axis by the revolving axis, and multiply the quotient by the difference, between three times the revolving axis, and twice the height of the segment.

2. Multiply the product thus found, by the square of the height of the segment, and this product again by .5236, and it will give the solidity required.

Examples.

In the oblate spheroid A, C, I, E, the transverse axis E, C, is 100, the conjugate A, I, 60, and the height of the segment, a, N, M, 12: what is the solidity

Here $156 = \text{diff of } 3 \times 21 \times 1\frac{2}{3} = \frac{100}{3} \times 144 =$
 $\text{square of height}) \times .5236 = \frac{156 \times 5}{3} \times 144 \times .5236 =$
 $52 \times 5 \times 144 \times .5236 = 260 \times 144 \times .5236 = 37440 \times$
 $.5236 = 19603.584 = \text{solidity required.}$

Required the content of the segment of a prolate
 spheroid: As height being 6 and the axis 50 & 30.
 Here $(\frac{50 \times 3}{2} - 6 \times 2) \div 3 \times \frac{30 \times 3}{30} \times 6^2 \times .5236 =$
 $\frac{90 - 12}{3} \times 50 \times 36 \times .5236 = 130 \times 36 \times .5236 =$
 $4680 \times .5236 = 2450.4480 \text{ ans.}^{\circ} \text{ required.}$

Problem 23rd

To find the solidity of an elliptic spheroid.
 Rule

First from 3 Times the square of the middle di-
 ameter, and 4 Times the square of the diameter,
 between the middle and the end; and from 5 Times
 this last diameter, take 3 Times the said middle

diameter; and $\frac{1}{4}$ of the quotient arising from dividing the former difference by the latter, and give the central distance.

2. Find the axes of the ellipsis by problem 2nd of conic sections, and the area of the generating segment, by problem 3th.

3. Divide 3 times the area thus found, by the length of the spindle, and from the quotient, subtract the middle diameter; then, multiply the remainder by 4 times the central distance, and subtract the product from the square of the middle diameter, and this difference, multiplied by 3 of the length of the spindle, and the product again by 1.57079, will give the solidity.

Examples.

What is the solidity of the elliptic spindle CG , the length CG , of which is 80, the middle diameter NK 24 & the diameter nm , at $\frac{1}{4}$ of the length 18.99094.

Here $(3 \times 24^2 - 10.99094^2 + 4 \div 10.99094 \times 4 - 3$
 $\times 24) \times \frac{1}{2} = 1728 - 1442.62320833 \div 75.96378$
 $- 72 \div \times \frac{1}{2} = 285.37679167 \div 3.96376 \times \frac{1}{2} =$
 $71.966 \times \frac{1}{2} = 17.999 = 18 \text{ nearly, for the central distance}$
 And $18 + \frac{24}{2} = 18 + 12 = 30 = \frac{1}{2} \text{ conjugate dist. And } \frac{20}{2} \times 30 \div$
 $\sqrt{30^2 - 18^2} = 40 \times 30 \div \sqrt{900 - 324} = 50 = \frac{1}{2} \text{ transverse}$
 And $\frac{12}{2 \times 30} = \frac{12}{60} = \frac{1}{5} = .2 = \text{tab say, the circular segment of}$
 which is $11823 \therefore 11823 \times 100 \times 60 = 11.1823 \times 60$
 $= 670.938 = \text{generating segment.}$
 Hence $24^2 - \left\{ \frac{670.938 \times 3}{180} - 24 \right\} \times 72 \text{ or } 40a = 24^2 -$
 $25.160175 = 24 \times 72 - 24^2 - 11.60175 \times 72 = 24^2 -$
 $835.326 = 576 - 835.326 = 492.4674$
 And $492.4674 \times \frac{20}{3} \times 157079 = 13132.464 \times$
 $1.57079 = 20628.34312656 = \text{solidity required.}$

The length of an elliptic spindle, is 40 The middle diameter 12, and the diameter at a quarter of the length, 9. 49546. which is the solidity. -

$$\begin{aligned} & \text{Here } (3 \times 12^2 - 9.49546^2 \times 4 \div 9.49546 \times 4 \times 0 \\ & - 3 \times 12)^{\frac{1}{4}} = 432 - 1442.62320833.360.6550 \\ & 424464 \div 37.90184 - 36)^{\frac{1}{2}} = 71.344957 \\ & 5536 \div 190184)^{\frac{1}{2}} = 36 \times \frac{1}{4} = 9 \text{ central distance} \\ & \text{And } 9 + \frac{12^2}{2} = 9 + 6 = 15 \frac{1}{2} \text{ conjugate. Likewise } 4^2 \\ & \times 15 \times (20 - 20) \div \sqrt{15^2 - 9^2} = 300 \div \sqrt{225} = 3724 \\ & = 300 \div 12 = 25 \frac{1}{2} \text{ transverse.} \end{aligned}$$

$$\begin{aligned} & \text{Also } \frac{60}{2} \times 13 - \frac{60}{30} = 2 = \text{radius, the circular segment} \\ & \text{of which is } 111023 \therefore 111023 \times 30 \times 60 = 3354690 \\ & \times 50 = 1677345 = \text{generating segment} \\ & \text{Where } 12^2 - \left[\left(\frac{1677345 \times 3}{40} - 124 \right) \times 36 \right] = 144 - \\ & 12.5800875 - 12 \times 36 = 5000875 \times 36 = \\ & 12311605 - \end{aligned}$$

$$\begin{aligned} & \text{And } 12311605 \times \frac{40}{3} \times 157079 = 164155754 \\ & \times 157079 = 25778421606566 = \text{ans. required} \end{aligned}$$

Problem 24th

To find the solidity of the middle frustum of an elliptic spindle; the length, the diameters of the middle and end, and another parallel thereto, and $\frac{1}{2}$ of the length of the frustum being given.

Rule.

1. From the sum of 3 times the square of the middle diameter, and the square of that of the end, take 4 times the square of the diameter between the middle and the end; and from 4 times the last diameter, take the sum of the least diameter, and 3 times that of the middle, and $\frac{1}{2}$ of the quotient arising from dividing the former difference by the latter, will give the central distance.

2. Find the axes of the ellipse by problem the 2nd and the area of the elliptical segment the chord of which is the length of the frustum by problem 5th —

3. Divide three times the area thus found by the length,

of the frustrum and from the quotient subtract the difference between the middle diameter, and that of the end, and multiply the remainder by 8 times the central distance.

4. Then from the sum of the square of the least diameter, and twice the square of that in the middle, take the product last found, and this difference multiplied by the length, and the product again by 261799, &c will give the solidity required.

Examples.

What is the solidity of the frustrum A, C, I, P , the length of which is 28, the middle diameter m, n 24, the diameter A, C of the end 21.6 and that A, i , $\frac{1}{4}$ of the length 23.40909?

$$\text{Here } \frac{24^2 \times 3 + (21.6)^2 - 4 \times (23.409)^2}{4 \times 23.409 - (21.6 + 3 \times 24)} = \frac{2194.56 - 21919.25124}{93.63636 - 93.6}$$

$$= \frac{2.632876}{.03636} = 72.46.$$

$$\text{And } \frac{72.46}{4} = 18.11 = 18, \text{ nearly} = \text{central distance g.w.}$$

$$\text{Also } \frac{30 (= \text{mg}) \times 14 (= \text{aw})}{\sqrt{30^2 \text{mg}^2 - 28.8^2 = (\text{g.w.}^2)} \sqrt{900 - 829.44}} = \frac{420}{\sqrt{70.56}} = \frac{420}{8.4}$$

$$= 50 = \frac{1}{2} \text{ transverse diameter.}$$

$$\text{And } \frac{1.2 (= \text{m})}{60 (= 2 \text{ trans})} = .02 = \text{Tab. vs; and } .003748 = \text{circular}$$

$$\text{segment belonging to } .02 \therefore .003748 \times 100 \times 60 = 22.488$$

$$= \text{elliptic segment of which, Am is the arc.}$$

$$\text{Thence } 24^2 \times 2 + (21.6)^2 - \frac{3 \times 22.488^2}{2.4} - 2.4 (= \text{diff of}$$

$$\text{mm} \times \text{AC}) \times 8 \times 18 = 1152 + 446.56 - (2.4094 - 2.4 \times 124)$$

$$= 1618.56 - .0094 \times 144 = 1618.56 - 1.3536 = 1617.2064$$

$$\text{And } 1617.2064 \times 20 (= \text{ac}) \times .261799 = 45281.779^2$$

$$\times .261799 = 11854.7245127008 = \text{solidity required.}$$

In the middle frustum of an elliptic spindle, the middle diameter is 32 the diameter at the end 24, and the diameter at $\frac{1}{4}$ of the length 30.15756, and the length 40 required the solidity.

$$\text{Hence } \frac{(32^2 \times) 3 + (24^2 \times) 4 - 4 \times (30 \cdot 15756^2)}{(4 \times 30 \cdot 15756) - (32 \times 3) - (12 \cdot 12)} =$$

$$\frac{3648 - 3637913700144}{12063024 - 120} = \frac{0872993856}{63024} = 14.8$$

And $\frac{14.8}{4} = 3.7 = 4 \text{ nearly} = \text{central distance}$

Also $4 + 16 = 20 = 1/2 \text{ conjugate}$. And $\frac{20 \times 20}{\sqrt{20^2 - 4^2}} = \frac{400}{\sqrt{400 - 16}}$
 $= \frac{400}{\sqrt{384}} = \frac{400}{20 \text{ nearly}} = \frac{800}{40} = 20 = \text{Nabular } \text{VS}; \text{ and trans.}$

Again $\frac{8}{20 \times 2} = \frac{8}{40} = 2 \text{ VS and } 111823 = \text{circular } \text{So}$

$$2 \therefore 111823 \times 4040 = 4472920 \times 40 = 1789168$$

= ship segment.

Thence $24^2 + (32^2) \times 2 = \frac{3 \times 1789168}{40} = 8$
 (diff between mid & end $\times 3.2 = 2048 + 576$

$$- (13.4 - 8 \times 32) = 2624 - 1748 = 2607 \text{ nearly}$$

And $2607.0 \times 40 \times 26179 = 1042800 \times 26179$
 $= 27300400409720 = \text{ans.}^2 \text{ required}$

Problem 25th

To find the solidity of a parabolic conoid.
Rule.

Multiply the area of the base, by half the altitude,
and the product will be the content.

Examples.

What is the solidity of the paraboloid $A P M$, the
height $M m$, of which is 42, and the diameter $J A$,
of its circular base 48?

$$\text{Here } 48^2 \times .7854 \times 42 (= \frac{1}{2} P m m) = 2304 \times .7854 \times 42 = 1809.5616 \times 42 = 76001.5872 = \text{ans}^r. -$$

What is the solidity of a paraboloid the height of which is 60, and the diameter of its circular base, 100?

$$\text{Here } 100^2 \times .7854 \times 30 = 10000 \times .7854 = 7854.0000 \times 30 = 235620 = \text{ans.}^{\text{r}} \text{ required.}$$

Required the solidity of a paraboloid conoid, the height of which is 30, and the diameter of its base 40?

$$\text{Here } 40^2 \times .7854 \times 15 = 1600 \times .7854 \times 15 = 1256.64 \times 15 = 18849.60 = \text{ans.}^{\text{r}} \text{ required.}$$

Required the solidity of a paraboloid conoid, the height of which is 50, and the diameter of its base 100?

$$\text{Here } 100^2 \times .7854 \times 25 = 10000 \times .7854 \times 25 = 7854.0000 \times 25 = 196350 = \text{ans.}^{\text{r}} \text{ required.}$$

Problem 26th

To find the solidity of the frustum of a paraboloid,
when its ends are perpendicular to the axis of the solid,

Rule.

Multiply the sum of the squares, & the diameters,
of the two ends, by the height of the frustum, and
the product again by .3927, and it will give the so-
lidity.

Examples.

Required the solidity of the parabolic frustum
A, B, I, P, the diameter AB of the greater end being
58, that of the lesser end I, P, 30 and the height A, P, 18?

$$\text{Here } (58^2 + 30^2) \times 10 \times 3927 = (3364 + 900) \times 10 \\ + 3927 = 4264 \times 10 \times 3927 = 76752 \times 3927 = \\ 30140.5104 = \text{solidity required.}$$

What is the solidity of the frustum of a parabolic conoid, the diameter of the greater end being 60, that of the less end, 48 and the distance of the ends 10.

$$\text{Here } (48^2 + 60^2) \times 10 \times 3927 = (3600 + 2304) \\ \times 10 \times 3927 = 5904 \times 10 \times 3927 = 106272 \times \\ 3927 = 41733.0144 = \text{ans}^r.$$

Problem 27th

To find the solidity of a parabolic spindle.

Rule

Multiply the square of the middle diameter by the length of the spindle and the product again by .418879, and it will give the solidity.

Examples.

The length of the parabolic spindle AC is 60, and the middle diameter PM , 34: what is the solidity?

Here $34^2 \times 60 \times .418879 = 1156 \times 60 \times .418879 = 69360 \times .418876 = 29,053.44744 = \text{solidity required}$

The length of a parabolic spindle is 9 feet and the middle diameter 3 feet: what is the solidity?

Here $3^2 \times 9 \times .418879 = 9 \times 9 \times .418879 = 81 \times .418879 = 33.929199 = \text{ans.}$

(Problem 20th

to find the solidity of the middle frustum,
of a parabolic spindle.

Rule.

Add 8 times the square of the middle diam-
eter, 3 times the square of the less, and 4 times
the product of those diameters, into 1 sum; then
this sum being multiplied by the length, and the
product again by .05236 will give the solidity.

Examples.

In the middle frustum C, T, P, W , of the parabolic spindle,
 A, K, W, R , the middle diameter W, R , is 36, the diam-
eter of the end C, T , 20 and the length 36 required the solidity.

Here, $\overline{36^2 \times 8} + \overline{20^2 \times 3} + \overline{4 \times 36 \times 20} = 10360 + 1200 + 2880 = 14440$.

And $14440 \times 36 \times 0.5236 = 520128 \times 0.5236 = 27233.90208 = \text{solidity required.}$

Required the solidity of the middle frustum of a parabolic spindle, the middle diameter being 32, and the diameter at the end 24, and the length 40?

Here, $\overline{24^2 \times 4} + \overline{32^2 \times 8} + \overline{32 \times 24 \times 4} = 1728 + 8192 + 3072 = 12992$.

And $12992 \times 40 \times 0.5236 = 519680 \times 0.5236 = 27210.44480 = \text{ans.}^r \text{ required.}$

Problem 29th

To find the solidity of an hyperboloid.
Rule.

Is the square of the radius of the base and the square of the middle diameter, between the base and the vertex; and this sum, multiplied by the altitude, and the product again by $.5236$ will give the solidity.

Examples.

In the hyperboloid $A'E'W'$, the altitude $E'R$, is 10 the radius AR of the base 12 and the middle diameter, VM , 15.8745. what is the solidity.

$$\begin{aligned}
 &\text{Here } 15.8745^2 + 12^2 \times 10 \times .5236 = 251.99975 \\
 &+ 144 \times 10 \times .5236 = 395.99975 \times 10 \times .5236 = \\
 &3959.9975 \times .5236 = 2073.454691 = \text{solidity}
 \end{aligned}$$

In an sq. frustum the altitude is 50, the radius
 of the base 52, and the middle diameter, 68,
 what is the solidity?

$$\begin{aligned}
 &\text{Here } 52^2 + 68^2 \times 50 \times .5236 = 4624 + 2704 \\
 &\times 50 \times .5236 = 366200 \times .5236 = 191742.32 = \\
 &\text{ans. required.}
 \end{aligned}$$

(17) 22
Problem 30th

To find the solidity of the frustum of an hyperbolic cone

Rule.

Add together the squares of the greatest, and least semidiameters, and the square of the whole diameter, in the middle then this sum being multiplied by the altitude, and the product again by .52359 will give the solidity.

Note: The content of any spindle, formed by the revolution of a conic section, about its axis, may be found by the following rule:

Add together the squares of the greatest, and least diameters, and the square of double the diameter, in the middle, between the two, and this sum, multiplied by the length and the product again by .1309, will give the solidity.

And the rule will never deviate, much from the truth, when the figure revolves, about any other line which is, not the axis.

Examples.

In the hyperbolic frustum A, E, I, M , the length eg , is 20 The diameter AE of the greater end 32, that IM of the less end 24 and the middle diameter, nm , 28.1708:
 require the solidity:

$$\begin{aligned} \text{Here } (16^2 + 12^2 + 28.1708^2) \times 20 \times 52359 &= (256 \\ + 144 + 793.3939) \times 20 \times 52359 &= 1193.5939 \\ \times 20 \times 52359 &= 23871.878 \times 52359 = \\ 12499.07660202 &= \text{solidity required.} \end{aligned}$$

What is the solidity of the frustum of any hyperbolic conoid, of which the greater diameter is 96 least diameter 54 the middle diameter 76.4264392 and the altitude 25?

$$\begin{aligned} & \text{Here } (48^2 + 27^2 + 76.4264392^2) \times 25 \times 52359 \\ & = 2304 + 729 + 5841105 \times 25 \times 52359 = \\ & 8874105 \times 25 \times 52359 = 221852625 \times \\ & 52359 = 11615981591775 = \text{ans}^n \end{aligned}$$

Required the solidity of the frustum of an hyperbolic conoid, the height being 12, the greatest diameter 10, the least diameter 0, and the middle diameter $8\frac{1}{2}$.

$$\begin{aligned} & \text{Here } (5^2 + 3^2 + 8.5^2) \times 12 \times 52359 = (25 + 9 + \\ & 72.25) \times 12 \times 52359 = 106.25 \times 12 \times 52359 = \\ & 1275 \times 52359 = 66758 = \text{ans}^n. \end{aligned}$$

What is the content of the middle frustum
of an hyperbolic spindle, the length being 20
the middle or greatest diameter 16, the diameter at
each end 12 and the diameter at $\frac{1}{4}$ of the length 14, $\frac{1}{2}$
Here $(6^2 + 8^2 + 14^2) \times 20 \times .52359 = (36 + 64$
 $+ 210.25) 20 \times .52359 = 310.25 \times 20 \times .52359 =$
 $6205 \times .52359 = 3248.87595 = \text{ans.}^{\text{r}} \text{ required.}$

Required the content of the segment of any spin
dle, its length being 10, the greatest diameter 8
and the middle diameter 6? -

Here $(8^2 + 6^2) \times 10 \times 1309 = (64 + 12^2) \times 10 \times$
 $1309 = (64 + 144) \times 10 \times 1309 = 208 \times 10 \times 1309$
 $= 2080 \times 1309 = 2722720 = \text{ans.}^{\text{r}} \text{ required.}$

Of the

Regular Bodies.

A regular body is a solid, contained under a certain number of equal and similar figures, that are planes.

The total number of regular numbers of bodies which can possibly be formed, is 5.

1. The Tetraedron, or regular pyramid, which has four triangular faces.

2. The Hexaedron, or cube, which has six square faces.

3. The Octaedron, which has eight triangular faces.

4. The dodecaedron, which has twelve pentagonal faces.

5. The Icosaedron, which has 20 triangular faces.

If the following figures be made of paste board, and the lines turned up, and glued together, they will represent the five regular bodies, here mentioned.

Problem 1st

To find the solidity of an Octahedron.

Rule.

Multiply $\frac{1}{12}$ of the cube of the linear side, by the square root of 2, and the product will be the solidity.

Examples.

The linear side of the Octahedron A, E, C, n , is 4, what is the solidity?

$$\text{Here } \frac{4^3}{12} \times \sqrt{2} = \frac{4 \times 4 \times 4}{12} \times \sqrt{2} = \frac{16 \times 4}{12} \times \sqrt{2} =$$

$$\frac{64}{12} \times \sqrt{1.414} = \frac{64 \times 1.414}{12} = \frac{90.496}{12} = 7.5413$$

= ans. required.

Required the solidity of a tetrahedron, the side of which is 6?

$$\text{Here } \frac{6^3}{12} \times \sqrt{2} = \frac{216}{12} \times \sqrt{2} = \frac{216 \times 1.414}{12}$$

$$\frac{305.424}{12} = 25.452 = \text{ans.}$$

Problem 2nd

To find the solidity of an octaedron.
Rule.

Multiply's of the cube of the linear side, by the square root of 2 and the product will be the solidity.

Examples.

What is the solidity of the octaedron, B, C, G, A
At the linear side of which is 4?

$$\text{Here } \frac{4^3}{3} \times \sqrt{2} = \frac{64}{3} \times \sqrt{2} = 21.3333 \text{ &c} \times \sqrt{2} = 21.3333 \text{ &c} \times 1.414 \text{ &c} = 30.16806 = \text{solidity required.}$$

Required the solidity of an octaedron, the side
of which is 8?

$$\text{Here } \frac{8^3}{3} \times \sqrt{2} = \frac{512}{3} \times \sqrt{2} = 241.3226 =$$

Ans. required.

Problem 3^d

To find the solidity of a dodecaedron.

Rules.

To 24 times the square root of 5, add 4.7, and divide
the sum by 40: then the square root of the quo-
tient, being multiplied by 5 times the cube of
the linear side, will give the solidity required.

Examples.

The linear side of the dodecaedron AEGM is
3: what is the solidity?

Here $\sqrt{\frac{21 \times 5 + 47}{40}} \times 27 \times 5 = \sqrt{\frac{21 \times 2.23606 + 47}{40}}$
 $\times 27 \times 5 = \sqrt{\frac{46.95726 + 47}{40}} \times 135 = 206.981 =$
 solidity required.

The linear side of a doodecaedron, is 4: what is the solidity?

Here $\sqrt{\frac{21 \times 5 + 47}{40}} \times 1 \times 5 = \sqrt{\frac{21 \times 2.23606 + 47}{40}} \times 5$
 $= \sqrt{\frac{46.95726 + 47}{40}} \times 5 = 1.5326 \times 5 = 7.6630 =$
 ans. required

Problem 4th

To find the solidity of an icosaedron.

Rule.

To 3 times the square root of 5, add 7 and divide the sum by 2; then the square root of this quotient, being multiplied by $\frac{5}{6}$ of the cube of the linear side, will give the solidity.

That is $\frac{5}{6} s^3 \times \sqrt{\left(\frac{7 + 3\sqrt{5}}{2}\right)} = \text{solidity when } s = \text{linear side.}$

Examples

1. The linear side of the icosahedron A, B, C, D, E, F, G, H, I, K, is 3: what is the solidity?

$$\begin{aligned} \text{Here } & \frac{3\sqrt{5}+7}{2} \times \frac{5 \times 3^3}{6} = \sqrt{\frac{3 \times 223606 + 7 \times}{2}} \times \\ & \frac{5 \times 27}{6} = \sqrt{\frac{670018 + 7 \times}{2}} \times \frac{5 \times 9}{2} = \sqrt{685409} \\ & \times 22.5 = 261803 \times 22.5 = 589056 = \text{solidity} \\ & \text{required.} \end{aligned}$$

Required the solidity of an icosahedron, the linear side of which is 1.

$$\text{Then } \frac{\sqrt{223606} (= \sqrt{5})}{2} \times 3.7 \times 1.5 \times 1 =$$

$$\frac{\sqrt{670810} \times 7}{2} \times 0.333 \text{ etc} = \frac{\sqrt{1370810}}{2} \times$$

$$0.333 \text{ etc} = 2.61001 \times 0.33333 \text{ etc} = 2.1816 =$$

ans. required.

Of
Cylindric Rings.
Problem 1st

To find the convex surface of a cylindric ring.

Rule.

To the thickness of the ring, add the inner diameter, and this sum being multiplied by the thickness, and the product again by 0.8696, will give the superficies required.

Examples.

The thickness of a cylindric ring is 3 inches, and the inner diameter 12 inches: what is the convex superficies.

Here $12 + 3 \times 3 \times 9.8696 = 15 \times 3 \times 9.8696 = 45 \times 9.8696 = 444.132 = \text{superficies required}.$

The thickness of a cylinder ring is 4 inches, and the inner diameter 18: what is the convex superficies.
 Here $18 + 4 \times 4 \times 9.8696 = 22 \times 4 \times 9.8696 = 88 \times 9.8696 = 868.5248 = \text{ans.}$

The thickness of a cylinder ring is 2 inches, and the inner diameter 18: what is the convex superficies.
 Here $18 + 2 \times 2 \times 9.8696 = 20 \times 2 \times 9.8696 = 40 \times 9.8696 = 394.784 = \text{ans.}$

Problem 2nd

To find the entire solidity of a regular cylinder ring.
 Rule.

To the thickness of the ring add the inner diameter, and this sum being multiplied by the square of $\frac{1}{2}$

the thickness, and then by 9.8696 will give the solidity.
 Examples.

What is the solidity of an anchor, ring the inner diameter of which is 8 inches, and thickness, in metal 3 inches.

$$\begin{aligned} \text{Here } 8 + 3 \times \frac{3}{2} &= 11 \times 1.5^2 \times 9.8696 = 11 \\ &+ 2.25 \times 9.8696 = 24.75 \times 9.8696 = 244.2726, \text{ in} \\ &= \text{solidity required.} \end{aligned}$$

The inner diameter of a cylindrical ring is 18 inches, and its thickness 4 inches: what is the solidity? -

$$\begin{aligned} \text{Here } 18 + 4 \times \frac{4}{2} &= 22 \times 2^2 \times 9.8696 = \\ 22 \times 4 \times 9.8696 &= 88 \times 9.8696 = 868.5248 = \text{ans.} \end{aligned}$$

Required the solidity of a cylindrical ring, the thickness of which is 2 inches, and inner diameter 16? -

$$\begin{aligned} \text{Here } 12 + 2 \times \frac{2}{2} &= 14 \times 1^2 \times 9.8696 = 14 \times 1 \\ \times 9.8696 &= 14 \times 9.8696 = 138.1744 = \text{ans.}^{\text{r}} \text{ required.} \end{aligned}$$

What is the solidity of a cylinder the thickness
of which is 4 inches, and inner diameter 16?

$$\begin{aligned}\text{There } 16 + 4 &\times \frac{4}{2}^2 \times 9.8696 = 20 \times 2^2 \times 9.8696 = \\ 20 \times 4 \times 9.8696 &= 80 \times 9.8696 = 789.568 = \text{ans}^r. \\ \text{required.}\end{aligned}$$

Of the,
Weight and Dimensions,
of
Balls and Shells.

The weights and dimensions of any ball or shell, can be had from experiments, the weight and dimensions of any other ball or shell, of the same kind, may be found by the following rules.

Problem. 1st

Having the diameter of an iron shot given, to find its weight.

Rule.

Take $\frac{1}{8}$ of the cube of the diameter in inches, and $\frac{1}{8}$ of that height $\frac{1}{2}$, and the sum, with the weight required, in pounds, exactly.

Examples.

The diameter of an iron shot is 3.5 inches, what is its weight.

$$\begin{aligned} \text{Here } 3.5 \times 3.5 \times 3.5 &= \frac{3.5^3}{8} = \frac{12.25 \times 3.5}{8} = \frac{42.875}{8} \\ &= 5.359 = \text{And } \frac{5.359}{8} + 5.359 = .669 + 5.359 = 6.028 \\ \text{lbs} = \text{ans.}^{\text{r}} \text{ required.} \end{aligned}$$

The diameter of an iron shot, is 6.7 inches; what is its weight?

$$\begin{aligned} \text{Here } 6.7^3 &= \frac{6.7 \times 6.7 \times 6.7}{8} = \frac{4.489 \times 6.7}{8} = \frac{30.0763}{8} = 37.595 \\ \text{And } \frac{37.595}{8} + 37.595 &= 4.699 + 37.595 = 42.294 \text{ lbs} = \text{ans.}^{\text{r}} \end{aligned}$$

Problem 2nd.

Having the diameter of a leaden ball given, to find its weight.

Rule.

Take $\frac{1}{8}$ of the cube of the diameter, and from it subtract $\frac{1}{8}$ of this third, and the remainder is the weight required.

nearly.

Examples.

What is the weight of a leaden ball the diameter of which is 3.3 inches?

$$\begin{aligned} \text{Here } \frac{3.3^3}{3} &= \frac{3.3 \times 3.3 \times 3.3}{3} = 9.9 + 9.9 \times 3.3 = 35.937 \\ &= 11.979. \text{ And } 11.979 + 11.979 = 11.979 + 3.993 \\ &= 7.986 = 8 \text{ lbs nearly} = \text{ans?} \end{aligned}$$

What is the weight of a leaden ball, the diameter being 5.24 inches.

$$\begin{aligned} \text{Here } \frac{5.24^3}{3} &= \frac{5.24 \times 5.24 \times 5.24}{3} = \frac{274.576 \times 5.24}{3} = \\ \frac{1438.77824}{3} &= 479.59274. \text{ And } 479.59274 + \\ 479.59274 &= 479.59274 + 15.693091 = 323061 \text{ lbs} \\ &= \text{ans? required} \end{aligned}$$

Problem 3rd

Having the weight of a leaden ball being given, to find the diameter.

Rule

To 4 times the weight add half the weight, and $\frac{3}{100}$ of half the weight, and the cube root of this sum will be the diameter, nearly.

Examples.

The weight of a leaden ball is 36 lbs what is the diameter.

$$\text{Here } (36 \times 4 + 18) + \frac{3}{100} \text{ of } 18 = 144 + 18 + \frac{54}{100} = 162 + 12 = 174.12$$

$$\text{And } \sqrt[3]{174.12} = 5.58 \text{ Or } 27 = 3 \text{ of } 3 \text{ (say assumed cube)} \times 2$$

$$+ 36.12 : 36.12 \times 2 + 27 :: 3 = (\text{assumed cube}) = 90.12 : 99.24$$

$$\therefore 3 = \frac{99.24 \times 3}{90.12} = \frac{297.72}{90.12} = 3.30 = \text{diameter required.}$$

What is the diameter of a leaden ball the weight being 12 lbs

$$\text{Here } (12 \times 4 + 6) + 18 = 48 + 6 + 18 = 72 + 18 = 90$$

$$72.18 = 3.74 \text{ inches} = \text{diameter required.}$$

Problemth

The weight of an iron ball being given to find the diameter.

Rule.

Multiply the weight by 7, and to the product add $\frac{7}{9}$ of the weight, and the cubed root of the sum will be the diameter in inches.

Examples.

The weight of an iron ball is 24 lbs what is the diameter.

Here $24 \times 7 + \frac{7}{9} \text{ of } 24 = \sqrt[3]{168 + 2.666} = \sqrt[3]{170.666} = 5.54 = \text{diameter required.}$

The weight of an iron ball is 12 what is the diameter.

Here $12 \times 7 + \frac{7}{9} \text{ of } 12 = \sqrt[3]{84 + 1.333} = \sqrt[3]{85.333} = 4.4 \text{ inches} = \text{diameter required.}$

Problem 5th

Having the external and internal dimensions
of an iron shell given, to find its weight.

Rule.

Take $\frac{1}{8}$ of the difference of the cubes of the diam.
in inches, and $\frac{1}{8}$ of the weight and their
sum will be the weight in lbs.

Examples

What is the weight of a 13 inch iron bomb shell
the metal being 2 inches thick on a mean?

$$\begin{aligned} \text{Here } \frac{13^3 + 9^3}{8} &= \frac{13 \times 13 \times 13 + 9 \times 9 \times 9}{8} = \frac{2197 + 729}{8} \\ &= \frac{2926}{8} = 365.75 \text{ And } \frac{105.5}{8} + 105.5 = 22.9 + 105.5 \\ &= 128.4 \text{ lbs} = \text{ans.} \end{aligned}$$

What is the weight of a 9 inch bomb shell the metal
being $\frac{1}{2}$ inch thick.

$$\begin{aligned} \text{Here } \frac{9^3 + 1.5^3}{8} &= \frac{729 + 2.25}{8} = \frac{731.25}{8} = 91.40625 \text{ And } \frac{64.125}{8} + 64.125 = 8.015625 + 64.125 \\ &= 72.140625 = \text{ans.} \end{aligned}$$

Problem 6th

To find the number of pounds of powder, that a hollow shell will hold.

Rule.

Cube the internal diameter, in inches and divide by 59.32, and the quotient is the weight nearly.

Examples.

How many pounds of powder will a hollow shell hold, the internal diameter of which is 9 inches

$$\text{Here } 9^3 \div 59.32 = \frac{9 \times 9 \times 9}{59.32} = \frac{729}{59.32} = 12.28 \text{ pounds} - \text{ans.}^r$$

How many pounds of powder will a hollow bomb-shell hold the internal diameter being 13 inches

$$\text{Here } 13^3 \div 59.32 = 2197 \div 59.32 = 37 \text{ lbs} = \text{ans.}^r$$

Problem 7th

To find the dimensions of a cubical box, to hold
a given quantity of powder

Rule

Multiply the weight in pounds, by 31.06, and
the cube root of the product, will give the length
of the side, in inches

Examples.

What must be the side, in length, of a cubical
box, that is, to hold 15 lbs of powder?

Here $\sqrt[3]{31.06 \times 15} = \sqrt[3]{465.90} = 7.75$ inches
= answer required

What is the side of a cubical box, that is to hold
12 lbs of powder? -

Here $\sqrt[3]{31.06 \times 12} = \sqrt[3]{372.72} = 7.19$ = ans. required

Problem 8th

Given the length, breadth, and depth of a rectangular box, to find how many lbs of powder will fill it.

Rule

Multiply the length, breadth, and depth in inches together; and this product being multiplied again by .0322, will give the answer in pounds, nearly.

Examples.

The length of a rectangular box is 15 inches the breadth 13 inches, and depth 5 in. how many lbs of powder will fill it?

Here $15 \times 13 \times 5 \times .0322 = 45 \times 5 \times .0322 = 975 \times .0322 = 31.395$ lbs = ans^r. required.

The length of a rectangular box is 1 foot, the breadth 9 in and depth 4 in: how many lbs of powder will it hold?

Here $12 \times 9 \times 4 \times .0322 = 108 \times 4 \times .0322 = 432 \times .0322 = 13.9104$ lbs = number of pounds required.

Problem 9th

Given the diameter, and length, of a hollow cylinder to
find how many pounds of gunpowder will fill it.
Rule.

Multiply the square of the diameter, by 10 of the length
and then take $\frac{1}{4}$ of the product, $\frac{1}{90}$ of this $\frac{1}{4}$ and $\frac{1}{90}$ of this last
and the sum of all these parts, will be the answer in pounds, nearly.

Examples.

The diameter of a hollow cylinder is 4 in. and the length
1 foot: how many pounds of powder, will it hold. -

Here $\frac{4^2 \times 12}{4} = 19.2 = 4.8$. And $\frac{4.8}{90} + 4.8 = 4.8533$
Also $4.8533 + \frac{0.533}{90} = 0.005 + 4.8533 = 4.8538 \text{ lbs} = \text{ans}^r$ -

The diameter of a hollow cylinder is 6 inches. and length 10
inches, how many lbs. of powder, will it hold. -

Here $\frac{6^2 \times 10}{4} = 90.00$ And $\frac{90}{90} \pm 9 = 1 + 9 = 9.1$ Also $1 \div \frac{1}{90}$
 $\pm 9.1 = .009 + 9.1 = 9.109 \text{ lbs} = \text{quantity of powder required.}$

Problem 10th

Given the diameter of a hollow cylinder, to find what length of it will be filled, by a given quantity of powder.

Rule.

1. Divide the weight in lbs. by the square of the diameter in inches.
2. Multiply the quotient by 40, and from the product subtract $\frac{1}{3}$ of the quotient.
3. From the remainder take $\frac{1}{3}$ of that third, and the last remainder will be the answer nearly.

Examples.

The diameter of a hollow cylinder is 1 foot, what length of it will be filled by 12 lbs of powder.

$$\text{Here } 10 \div 144 \text{ (sq of diam)} = 10 \div 12 \times 12 = .0694416.$$

$$\text{And } .0694416 \times 40 = .0231472 \text{ (} \frac{1}{3} \text{ of } .0694416 = 2.7777664 \\ - .0231472 = 2.7545160.$$

$$\text{Also } 2.7545160 - .0077157 = (\frac{1}{3} \text{ of } .0231472) = 2.74680011 = \text{in. and } \frac{1}{1000}$$

The diameter of a hollow cylinder is 6 inches: what length of it will be filled by 12 lbs of powder. —

Here $12 \text{ lbs} \div 6^2 = 12 \div 36 = .333 = 12 \text{ lbs divided by sq. of diam.}$

Also $.333 \times 40 = 13.333 - 111 = 13.219$.

And $13.219 - .037 = (.30 \div 111) = 13.182 = \text{ans. required in inches.}$

Of the
Piles
of
Balls and Shells.

Iron shot, and shells, were usually piled in horizontal courses, in a pyramidal or wedge like form, the base being either an equilateral triangle, a square, or a rectangle. In the triangle and square, the pile finishes in a single ball; but in the rectangle the top is a single row of balls.

In triangular courses of piles or squares the number of horizontal rows is always equal to the number of shot on one side, in the bottom row. But in rectangular piles, the number of courses is equal to the number of shot in the breadth of the bottom row and the number in the

top row less 1 is the difference between the number in the length and breadth of the bottom row.

Problem 3rd

To find the number of shot in a finished triangular pile.

Rule.

Multiply the number in one side of the bottom row, plus 2, by that number plus 1; and this product being again multiplied by $\frac{1}{6}$ of the number in the said row, will give the answer required.

Examples

Required the number of shot in a finished triangular pile, the number in one side of the base being 20?

$$\text{Here } \left\{ \begin{array}{l} 22 = \text{number plus 2} \\ 21 = \text{number plus 1} \end{array} \right\} \times \frac{20}{6} = \frac{22 \times 21 \times 20}{6} = \frac{462 \times 20}{6} = \frac{9240}{6} = 1540 = \text{number of shot in whole pile.}$$

Required the number of shot in a finished triangular pile, the number in one side of the base being 40.
 There is 2 number plus 21 + 41 number plus 11 + 40
 $\therefore 6 \{ \text{of } 40 \} = \frac{42 \times 41 \times 40}{6} = \frac{1722 \times 40}{6} = 11480$
 shot in the pile.

Problem 2nd -

To find the number of shot in a finished square pile.

Rule.

Multiply the number in one side of the bottom square by double that number plus 1, and this product being multiplied by 6 of the said number, will give the answer required.

Examples

Required the number of shot in a finished square pile the number in one side of the base being 20.

There is $41 = (20 \times 2 + 1) \times 21 \div (20 + 1) \times 20 \div 6 = 2870$, number req.

Required the number of shot in a finished square
 pile, one side of the lower tier having 49 shot in it. -

$$16c \{ 81 (= 4 \times 2 + 1) \times 41 (= 40 + 1) \times 40 \} \div 6 \quad \begin{array}{r} 3321 \times 40 \\ 6 \end{array}$$

$$= \frac{132840}{6} = 22140 = \text{number of shot in the pile}$$

Problem 3rd

To find the number of shot in a finished rectangular
 pile.

Rule.

1. To twice the number in the uppermost row add
 the number of courses less one, and multiply the
 sum by the number of courses plus 1.
2. Multiply the number of courses less one by that
 number more one and add $\frac{1}{3}$ of this product to
 the former.
3. Take a fourth of this last sum, and multiply
 it by the number of courses, and it will give the
 answer required. -

Examples.

How many shot are there in a finished, rectangular pile, of 15 courses, the number in the uppermost row being 32?

$$\text{Row } 32 \times 2 + 14 = (\text{number of courses less } 1) \times 16 = (\text{number of courses plus } 1) = 64 + 14 \times 16 = 78 \times 16 = 1248$$

$$\text{And } (14 = (\text{number of courses less } 1) \times 16) \div 3 = 3 + 1248$$

$$\frac{324}{3} + 1248 = 74\frac{2}{3} + 1248 = 1322\frac{2}{3}.$$

$$\text{Also } 1322\frac{2}{3} \div 4 = (\frac{1}{4} \text{ of } 1322\frac{2}{3}) \times 15 = 330\frac{2}{3}$$

$$\times 15 = 4960 - \text{number of shot in the pile} =$$

(Answer required) -

How many shot are there in a finished rectangular pile, of 20 courses the number in the top row being 40.

$$\text{Here } 40 \times 2 + 19 = (\text{number of courses less } 1) \times 21 (= \text{number of courses plus } 1) = 80 + 19 \times 21 = 2079 \times 21 = 2212$$

And $\{19 (= \text{number of sources } 6+1) \times 21 = \text{number of cour-}$
 $\text{ses plus } 1 \div 3\} + 2079 = 2212.$

And $2212 \div 4 \times 20 = (\frac{1}{4} \text{ of } 2212) \times 20 = 553 \times 20 =$
 $11060 = \text{number of photo in the file.}$

Of Artificers Work.

Artificers estimate or compute the value of
their works by different measures, viz.

- 1 Glazing and Mason's flat work, &c by the foot
 - 2 Vaulting, plastering & paving &c by the yard.
 - 3 Flooring, partitioning, roofing, tiling &c by the sq. of 100 ft.
 - 4 Brickwork, &c by the rod of 16 1/2 feet the sq. of which is 27 1/4
- The measures, made use of in these works are in the following table

12 inches	1 lineal foot.
14 1/2 inches	1 square foot.
144 square feet	1 square yard
106 square feet	1 square of flooring &c
27 1/4 square feet or	1 rod perch or
30 1/4 square yards.	1 square pole.

Of Timber Measure.

Problem 1st -

To find the area, or superficial content, of a board, or plank.

Rule.

Multiply the length by the breadth, and the product will be the content required. -

Note. When the board is tapering, add the breadths of the two ends together, and take $\frac{1}{2}$ the sum for the mean breadth.

Examples.

What is the value of a plank, the length of which is 8 feet 6 inches, and breadth 1 foot 3 inches throughout, at $2\frac{1}{2}$ per foot.

Here $8\frac{6}{12} \times 1\frac{3}{12} = 10$ feet 7 in 6 parts = content.

And $10\frac{7}{12}$ ft 6 p at $2\frac{1}{2}$ per foot = 2s. $2\frac{1}{2}$ = answer. -

What is the content of a board, the length of which is 5 feet 7 inches, and breadth 1 foot 10 inches.

Here $5 \text{ f. } 7 \text{ in.} \times 1 \text{ f. } 10 \text{ in.} = 10 \text{ f. } 2 \text{ in. } 10 \text{ p.} = \text{ans}^r$

At $1 \frac{1}{2} \text{d}$ per foot, what is the value of a plank, the length of which is 12 f. 6 in, and breadth 11 inches throughout.

Here $12 \text{ f. } 6 \text{ in.} \times 11 \text{ in.} = 11 \text{ f. } 6 \text{ in. } 6 \text{ p.} = \text{content.}$

And $11 \text{ f. } 6 \text{ in. } 6 \text{ p.}$ at $1 \frac{1}{2}$ per foot = $1 \text{ s. } 5 \frac{1}{2} \text{d.} = \text{ans}^r$

Find the value of 5 oaken planks at 3 d. per foot, each being $17 \frac{1}{2}$ feet long, and their particular breadths as follows: viz. two of $13 \frac{1}{2}$ in. in the middle, one of $14 \frac{1}{2}$ in the middle, and the two remaining ones each 18 inches at the broader end, and $11 \frac{1}{4}$ at the narrower end.

Here $17 \frac{1}{2} \text{ f.} \times 13 \frac{1}{2} \text{ in.} \times 2 = 236 \text{ f. } 3 \text{ in.} \times 2 = 472 \text{ f. } 6 \text{ in.}$

And $17 \frac{1}{2} \text{ f.} \times 14 \frac{1}{2} \text{ in.} = 253 \text{ f. } 9 \text{ in.}$

Also $17 \frac{1}{2} \times \frac{11 \frac{1}{4} + 18}{2} \times 2 = 17 \frac{1}{2} \times \frac{29 \frac{1}{4}}{2} \times 2 = 253 \text{ f. } 9 \frac{1}{2} \text{ p.} \times 2 = 507 \frac{1}{2} \text{ f. } 9 \text{ in.}$

And $472 \text{ f. 6 in.} + 253 \text{ f. 9 in.} + 507 \text{ f. 6 in.} = 1233 \text{ f. 9 in.}$
 Hence. $1233 \text{ f. 9 in. at } 3\text{d per yard} = \text{£. } 5\text{s. } 8\text{d.} =$
 ans^r required.

Problem 2nd

To find the solidity of square, or four sided timber.
 Rule.

Multiply the mean breadth by the mean thick-
 ness, and this product again by the length, and it
 will give the solidity required.

Examples.

The length of a piece of timber is $20\frac{1}{2}$ feet; the breadth
 at the greater end is 1 foot 9 inches, and the thickness
 1 foot 3 inches; and at the less end the breadth is 1
 foot 6 inches, and thickness 1 foot; what is the solidity
 Here $1.75 \text{ greatest breadth} + 1.5 = \text{less breadth} \div 2 = 3.25 \div$
 $= 1.625 = \text{mean breadth.}$

And $1.25 \text{ greater thickness} + 1 = \text{less thickness} \div = 1.125 =$
 mean thickⁿ.

$$\text{Also } 1.625 \times 1.25 \times 20\frac{1}{2} (= \text{length}) = 1.828125 \times 20.5 = 37.4765625 \text{ feet} = \text{solid content} = \text{ans.}^{\text{r}} \text{ required.}$$

The length of a piece of timber, is 24.5 feet, and its ends are equal squares, the sides of which are each 1.04 feet: what is the solidity?

$$\text{Here } 1.04 \times 1.04 \times 24.5 = 1.0816 \times 24.5 =$$

$$26.59920 = 26\frac{1}{2} \text{ cu ft } 10 \text{ p } 10 \text{ in.}^{\text{th}} \text{ content in solid.}$$

ans. required.

The length of a piece of timber is 20.38 feet, and the ends are unequal squares, the side of the greater being 19' 8" and that of the less 9' 8" in: what is the solidity?

$$\text{Here } 19' 8" = \text{side of greater} \div 2 \text{ } 9' 8" = \text{side of less} \div 2 = 29 \div 2 = 14.5 = \text{mean breadth and thickness}$$

$$\text{And } 14.5 \times 14.5 \text{ in.} \times 20.38 \text{ feet} = 210.25 \text{ in.} \times 20.38 \text{ feet} = 29\frac{1}{2} \text{ cu ft} = \text{content} = \text{ans.}^{\text{r}} \text{ required.}$$

The length of a piece of lumber is 27.36 feet, at the greater end the breadth is 1.78 feet, and the thickness 1.23 feet; and at the less end the breadth is 1.04 feet and the thickness .91 feet. What is the solidity.

Here $1.78 = \text{greater breadth} + 1.04 = \text{less breadth} = \frac{2.82}{2}$
 $= 1.41 = \text{mean breadth.}$

And $1.23 = \text{greater thickness} + .91 = \text{less thickness} \div 2$
 $= 2.14 \div 2 = 1.07 = \text{mean thickness.}$

Also $1.41 \times 1.07 \times 27.36 (= \text{length}) = 1.5007 \times$
 $27.36 = 41 \text{ feet } 2 \text{ in } 3 \text{ p} = 41.277532 = 41 \text{ feet } 3 \text{ in } 3 \text{ p} =$
ans. required.

Problem 3rd

To find the solidity of round, or unsquared timber.
Rule 1st -

Multiply the square of the quarter girth (or $\frac{1}{4}$ of the circumference) by the length, and the product will be the content, according to the common practice.

Examples.

A piece of lumber is $9\frac{3}{4}$ feet long, and the greater girt 3 times as much: what is the solidity?

$$\text{Here } 3.25 \times 3.25 \times 9.75 \text{ feet} = 10.5625 \times 9.75 = 102.904375 = \text{solidity. ans.}^x$$

The length of a tree is 25 feet and the girt through out $2\frac{1}{2}$ feet: what is its solidity?

$$\begin{aligned} \text{Here } 2.5 \div 4^2 \times 25 &= 625^{\text{th}} \times 25 = 625 \times 625 \times 25 \\ &= 390625 \times 25 = 9765625 \text{ feet} = 9 \text{ feet } 9 \text{ in } 2 \frac{1}{2} \text{ 12ths} \\ &= \text{solidity} = \text{ans.}^{\text{r}} \text{ required} \end{aligned}$$

The length of a tree is $14\frac{1}{2}$ feet and its girt in the middle, 3.15 feet: required the solidity?

$$\begin{aligned} \text{Here } 3.15 = (\text{girt}) \div 4^2 \times 14.5 &= 7875^2 \times 14.5 = 7875 \\ &\times 7875 \times 14.5 = 62015625 \times 14.5 = 8992265625 = \\ &8 \text{ f. } 11 \text{ in } 10 \text{ p. } 10. \frac{12^{\text{ths}}}{10} = \text{solidity required.} \end{aligned}$$

The girth of a tree in 4 different places are as follows.
 in the 1st place, 5 feet 9 inches, in the second 4 feet 8 inches
 in the third 4 feet 9 inches, and in the fourth 3 feet
 9 inches; and the length of the whole tree is 15
 feet: what is the solidity.

$$\text{Here } \frac{(4 \text{ ft. } 5 \text{ in. } 4 \text{ ft. } 5 \text{ in. } 4 \text{ ft. } 9 \text{ in. } 3 \text{ ft. } 9 \text{ in.})}{4} = 4 \text{ ft. } 10 \text{ in. } 3 \text{ in. } 4 \text{ in.} =$$

$$4 \text{ ft. } 10 \text{ in. } = \text{mean proportional} = 1 \text{ ft. } 2 \text{ in. } = \frac{1}{4} \text{ of circumference}$$

$$\text{And } 1 \text{ ft. } 2 \text{ in.}^2 \times 15 \text{ ft.} = 1 \text{ ft. } 2 \text{ in.} \times 1 \text{ ft. } 2 \text{ in.} \times 15 \text{ ft.} = 1 \text{ ft. } 4 \text{ in. } 4 \text{ in.} \times 3 \times 5 =$$

$$4 \text{ ft. } 1 \text{ in. } 0 \text{ in.} \times 5 = 20 \text{ ft. } 5 \text{ in.} -$$

An oak tree is 45 feet 7 inches long, and its quarter
 girth 3 feet 8 inches: what is the solid content allow-
 ing 12 for the bark.

$$\text{Here } \frac{3 \text{ ft. } 8 \text{ in.} \times 4}{12} = 4 = \frac{14 \text{ ft. } 0 \text{ in.}}{12} = \frac{14 - 1 \text{ ft. } 2 \text{ in. } 0 \text{ in.}}{4} =$$

$$\frac{13 \text{ ft. } 5 \text{ in. } 4 \text{ in.}}{4} = 3 \text{ ft. } 4 \text{ in. } 4 \text{ in.}^2 \times 45 \text{ ft. } 7 \text{ in.}$$

$$\text{And } 3 \text{ ft. } 4 \text{ in. } 4 \text{ in.}^2 \times 45 \text{ ft. } 7 \text{ in.} = 11 \text{ ft. } 3 \text{ in. } 6 \text{ in. } 9 \text{ in.} \times 45 \text{ ft. } 7 \text{ in.} =$$

$$514 \text{ ft. } 11 \text{ in. } 4 \text{ in. } 8 \text{ in. } 12 \text{ in.} = \text{content} = \text{ans.} -$$

Rule 2nd

Multiply the square of 30 the girt by twice the length, and the product will be the solidity, expressed near the truth.

Examples

A piece of timber is $9\frac{3}{4}$ feet long, and 3 of the girt is 2.6 feet: what is the solidity.

$$\begin{aligned} \text{Here } 2.6^2 \times 9\frac{3}{4} \text{ feet} \times 2 &= 2.6 \times 2.6 \times 9.75 \times 2 = \\ 6.76 \times 9.75 \times 2 &= 65.9100 \times 2 = 131.8200 \text{ feet} = \\ 131 \text{ feet } 9 \text{ in } 10 \text{ p} &= \text{ans}^{\text{r}} \text{ required.} \end{aligned}$$

If the length of a tree be 24 feet, and the girt throughout 8 feet: what is the content.

$$\begin{aligned} \text{Here } 8 \div 5^2 \times 24 \times 2 &= 1.6 \times 1.6 \times 24 \times 2 = \\ 2.56 \times 24 \times 2 &= 61.44 \times 2 = 122.88 = 122 \text{ feet } 10 \text{ in } \\ 6 \text{ p } 8 \text{ in } &= \text{solidity of tree} = \text{ans}^{\text{r}} \text{ required.} \end{aligned}$$

If a tree quit 14 feet at the thicker end, and 2 feet at the smaller end; required the solidity when the length is 24 feet.

$$\begin{aligned} \text{Here } \frac{14 + 2}{2} &= 5^2 \times 24 \times 2 = \frac{16^2}{2} \times 24 \times 2 = \frac{8^2}{5} \times 24 \times 2 \\ &= 1.6 \times 1.6 \times 24 \times 2 = 2.56 \times 24 \times 2 = 614.4 \times 2 = \\ 1228.8 \text{ feet} &= 122 \text{ feet } 10 \text{ in } 6 \text{ } 8.12^{\text{th}} \text{ solidity.} \end{aligned}$$

A tree quits in 5 different places, as follows:
 in the first place 9.43 feet, in the second 7.92 feet
 in the third 6.15 feet, in the fourth 4.74 feet &
 in the fifth 3.16 feet, and the whole length 17.25 feet
 what is the solidity?

$$\begin{aligned} \text{Here } \frac{9.43 + 7.92 + 6.15 + 4.74 + 3.16}{5} &= 5^2 \times 17.25 \times 2 \\ &= \frac{31.40^2}{5} \times 17.25 \times 2 = \frac{6.20^2}{5} \times 17.25 \times 2 = 1.256 \times \\ 1.256 \times 17.25 \times 2 &= 1.577536 \times 17.25 \times 2 = 27.212490 \\ \times 2 &= 54.424992 \text{ feet - solidity} = 54 \text{ feet } 5 \text{ in } 1 \text{ p. } 1.12^{\text{th}} \\ &= \text{ans. required.} \end{aligned}$$

Of Bricklayers Work.

Bricklayers compute, or, value their work at the rate
of a brick and a half thick, and if a wall be, more or
less than this Standard, it must be reduced to it as
follows:

Rule.

Multiply the superficial content of the wall, in
feet, by the number of half bricks in thickness, and
 $\frac{2}{3}$ of that product, will be the content required.

Examples.

How many square rods, are there in a wall, $52\frac{1}{2}$ feet
long, 12 feet 9 inches high, and $2\frac{1}{2}$ bricks thick.

Here $[52.5 (- 52\frac{1}{2}) \times 12.75 = (12\text{ ft. } 9\text{ in.})] \div 272 (= \text{there being very}$
seldom used in practice) $= 669.375 \div 272 = 2.4609$.

And $2.4609 \times 5 \div 3 = 12.3045 \div 3 = 4.1015 = 4\frac{1}{4}, 27\frac{1}{2}\text{ in} = \text{an.}$

long, 14 feet 8 inches high, and 2 1/2 feet thick.

Here, $62 \times 6 \times 14 \times 8 = 272 \times 916 \div 272 = 3 \times 100 \times 8$

Find $\frac{3 \cdot 100 \cdot 8 \times 5}{3} = 16 \cdot 231 \cdot 4 \div 3 = 5 \cdot 167 \cdot 5 \cdot 2 =$

and required

If each side wall is a building, 64 1/2 feet long, on the outside, each end wall 15 feet broad on the inside, the height of the building 20 feet, and the gate at each end of the wall 6 feet high, the whole being 2 bricks thick; what is the true content in standard rods.

Here $\frac{45 \times 20 \times 4}{3} \times 2 = \frac{900 \times 4 \times 2}{3} = \frac{3600 \times 2}{3} = 1300 \text{ ft.}$
 Sides $\times 2 = 2600 = \text{The two sides.}$

And $\frac{15 \times 6 \times 4 \times 2}{3} = 130 = (\text{pence}) \times 2 = 260 = 2 \text{ ends}$.

Also $\frac{15 \times 14 \times 4}{3} \times 2 = 280 = (1 \text{ fable}) \times 2 = 560 = 2 \text{ fables}$

$$\text{Hence } (2600 + 560 + 260) 272 = \frac{3420}{272} = 12.573 =$$

$12 \cdot 155 \cdot 10 \cdot 1 \cdot 12^{\text{th}} = \text{ans. required!}$

Of Masons Work.

To Masonry, belongs all sorts of stonework, and the measure made use of is a foot, either superficial or solid.

Walls, blocks of marble or stone, columns &c. are measured by the solid foot; and pavements, slabs, chimney pieces &c. by the superficial foot.

Examples.

Require the solid content of a wall, the length of which is 48 f. 6 in, its height 10 f. 9 in and thickness 2 feet?

Here $48.5 \times 10.75 \times 2 = 5213.5 \times 2 = 10427.50 = \text{ans.} =$

1042 f. 9 in = 2 Ans.

Required the solid content of a wall, the length being 53 ft 6 in
its height 12 ft 3 in and its thickness 2 feet.

Here $53 \frac{1}{2} \times 12 \frac{1}{2} \times 2 = 655 \frac{3}{4} \times 2 = 1310 \frac{1}{2}$ cu in = Ans.

What is a marble slab worth, the length is 5 ft 7 in and
breadth 1 ft 10 in at 6s. per foot.

Here $5 \frac{7}{12} \times 1 \frac{10}{12}$ at 6s per foot = $10 \frac{1}{2} \times 10$ at 6s = £3 1 5 = ans.

What is the solid content of a wall, the length being 60 ft 9 in
its height 10 ft 3 in and its thickness 2 1/2 feet.

Here $60 \frac{3}{4} \times 10 \frac{1}{2} \times 2 \frac{1}{2} = 622 \frac{1}{2} \times 2 \frac{1}{2} = 1556 \frac{1}{4}$ cu in = ans.

In a chimney piece suppose the:

Length of the mantle and slab each 4 ft 6 in	}	Length of each jamb 4 ft 4 in
Breadth of both together — 3 ft 2 in		Breadth of both — 1 ft 9 in

Here $4 \frac{1}{2} \times 3 \frac{1}{2} \times 2 = 4 \frac{1}{2} \times 1 \frac{1}{2} \times 2 = 7 \frac{1}{2}$ cu in
 $1 \frac{1}{2} \times 4 \times 2 = 12$ cu in
mant. & slab

And $4 \times 1 \frac{1}{2} \times 2 = 4 \times 10 \frac{1}{2} \times 2 = 3 \frac{1}{2} \times 9 \frac{1}{2} \times 2 = 7 \frac{1}{2}$ cu in = jambs.

Whence $7 \frac{1}{2} + 14 \frac{1}{2} = 22$ cu in = answer required.

Of Carpenter's and Joiner's Work.

Carpenter's and Joiner's work, is that of flooring,
siding, lining, roofing &c, and is measured by the square of
100 feet.

Examples.

A floor be 57 feet 3 inches long, and 28 feet 6 inches
broad: how many squares will it contain.

$$\text{Here } 57.25 \times 28.5 = \frac{1631.625}{100} = 16.31625 = \text{ans.}^{\text{r}} \text{ req.}^{\text{d}}$$

A floor is 53 feet 6 inches long, and 47 feet 9 inches broad
how many squares will it contain.

$$\text{Here } 47.75 \times 53.5 = \frac{2554.625}{100} = 25.54625 = \text{ans.}^{\text{r}} \text{ req.}^{\text{d}}$$

required squares.

A partition is 91 feet 9 inches long, and 11 feet 3 inches broad: how many squares will it contain.

$$\text{Here } \frac{91.75 \times 11.25}{100} = \frac{1032.1875}{100} = 10.321875 = \text{ans.} -$$

If a house within the walls, 52 feet 8 inches in length, and 30 feet 6 inches in breadth, and the roof be of a true pitch, what will it cost roofing at 10s 6d per square.

$$\begin{aligned} \text{Here } (52.8 \times 22.10.6) &= \frac{30.6 \times 3}{4} \div 100 \text{ at } 10.6 = \\ \frac{1212.8.5}{100} \text{ at } 10.6 &= 12.12.8.9 \text{ at } 10.6 = \\ £12.12.11\frac{3}{4} &= \text{ans.} - \end{aligned}$$

Plaster and Tilers' Work.

In these works, the content of a roof is found by multiplying the length of the ridge, by the girt from eave to eave; and, in taking allowance must be made for the double row at bottom.

In taking the girt, the line is made to pl. over the low side of slates, and to run up the under side till it meet with the wall or eaves-board; but in taking the line is stretched down only to the lowest part, without returning it up again.

Double measure is generally allowed for hips, valleys, gutters &c but no deductions are made for the chimnies &c. -

Examples. -

In a house the length of a slated roof is 45 feet 9 inches and its girt 34 feet 9 inches: what is the content. -

$$\text{Here } 45.75 \times 34.25 = 1566.9375 = 174.104 \text{ qrs.}$$

$$174 \text{ qrs. } 0 \text{ feet } 11 \text{ in. } 2 \text{ p.} - \text{ans.}$$

What will the tiling of a barn cost, at 25s. 6d per square, the length being 43 feet 10 inches, and the breadth 27 feet 5 inches, on the flat, the eave boards projecting 16 inches on each side?

$$\text{Here } 43.10 \times 27.5 + \frac{27.5}{2} + (16 \text{ in.} = \text{eaves}) = 43.10 \times$$

$$42.5.6 = 1861 \text{ f. } 1 \text{ in. } 15 \text{ p.}$$

$$\text{And } 1861 \text{ at } 25.6 \text{ per square} = 1861 \text{ at } 25.6 =$$

$$\text{£ } 47.2.6 \frac{3}{4} = \text{Ans. required.}$$

Of Plasterers' Work.

Plasterers' work is of two kinds, viz. plastering upon laths, called ceiling; and plastering upon walls, called rendering; and these must be measured separately, and their contents collected into one sum.

Note. Proper deductions, must be made for doors, windows, &c. - And, in, measuring between quarters; there is commonly $\frac{1}{2}$ part of the whole area allowed; but when rendering between quarters is whitened or coloured, there is $\frac{1}{2}$ part to be added to the whole for the sides of the quarters and braces.

Examples.

If a ceiling be 59 feet 9 inches in length, and 24 feet 6 inches in breadth: how many yards of plastering does it contain?

Here $59.75 (= 59 \text{ feet } 9 \text{ inches}) \times 24.5 (= 24 \text{ feet } 6 \text{ inches}) = 59.75 \times 24.5 = 1463.875$

And $1463.875 \div 9 (= \text{number of square feet in a yard}) = 162.652 \text{ yards} = 162 \text{ yards } 5 \text{ feet } 10 \text{ in } 4 \text{ p. nearly} =$

Ans: required.

If the partitions between rooms, be 141 feet 6 inches about, and 11 feet 3 inches high: how many yards do they contain?

Here $141.5 (= 141 \text{ feet } 6 \text{ in}) \times 11.25 (= 11 \text{ f. } 3 \text{ in}) = 1591.875 \text{ feet}$

And $\frac{1591.875}{9} = 176.875 \text{ yds} = 176 \overset{\text{yds.}}{\underset{9}{\text{ft.}}} 11 \overset{\text{in.}}{\underset{8}{\text{ft.}}} =$
 = Ans?

There is a quantity of partitioning, that measures
 234 feet 8 inches about, and 14 feet 6 inches high
 and is situated between quarters; the lathing and
 plastering of which will be 8d per yard and the
 whitening 2d per yard: what will the whole come to
 Here $(234 \text{ f. } 8 \text{ in} + 14 \text{ f. } 6 \text{ in} + 234 \text{ f. } 8 \text{ in} + 14 \text{ f. } 6 \text{ in}) \div 5$
 $= (3402.8 + 3402.8) \div 5 = 3042.8 + 680.64 = 453.82$
 Also $453.82 \text{ at } 8 \text{ d.} + 453.82 \text{ at } 2 \text{ d.} = 3640 +$
 $910 = 4550 \text{ £ } 13. 19. 2 = \text{Ans}^{\text{r}} \text{ required.}$

The length of a room is 14 feet 6 inches, its breadth
 13 feet 2 inches, and its height 9 feet 3 inches,
 to the under side of the cornice. The girth of which
 is 8 1/2 inches, and its projection 5 inches from the
 wall on the upper part next the ceiling: what will
 be the quantity of plastering, supposing there are
 no deductions but for a door, the size of which is
 7 feet by 4 feet.

Here 14th 5ⁱⁿ - 10 (= 2 x 5 cornice) + 13.. 2 - 10 =

$$13.. 7 + 12.. 4 = 167.. 6.. 6$$

And 167th 6ⁱⁿ 6th = 18th 5ⁱⁿ 6th 6th = Cretling

$$\begin{aligned} \text{Also } 14.. 5 + 9.. 3 \times 2 + 13.. 2 + 9.. 3 \times 2 &= (\text{1 side } \times 2) \\ &= 133.. 4.. 3 \times 2 + 121.. 7.. 6 \times 2 = 266.. 8.. 6 + 242.. 7 \\ &= 510.. 3.. 6 = \end{aligned}$$

$$\begin{aligned} \text{And } 4.. 5 + 13.. 2 + 510.. 3.. 6 - 4 \times 7 (= \text{door}) \div 9 \\ = 510.. 3.. 6 - 28 \div 9 = 482.. 3.. 6 \div 9 = 53.. 6.. 3.. 6 = \end{aligned}$$

rendering.

$$\text{Hence } 14.. 5 + 14.. 5 + 13.. 2 + 13.. 2 + 18 \frac{1}{2} \text{ in} = 39.. 1 = \text{cornice.}$$

$$\begin{aligned} \text{And } 18.. 5.. 6.. 6 = \text{Cretling} - 530.. 5.. 3.. 6 = \text{rendering} \\ 39.. 1 = \text{Cornice} = \text{Answers required.} \end{aligned}$$

Painters' Work.

Painters' work is measured in the same manner as that of Joiners, and in taking the dimensions the lines must be joined into all the mouldings and corners.

Windows are done at so much a piece, and in carved mouldings &c. it is customary to allow double the usual measure.

Examples.

If a room be painted, the height, being 16 feet 6 inches, and its compass, 97 feet 7 inches: how many yards does it contain.

Here $97 \frac{7}{9} \times 16 \frac{5}{8} = 179 \cdot 208 \text{ yds}$ or $179 \cdot 1^{\text{ds}} \cdot 10^{\text{in}} \cdot 5^{\text{pr}} = \text{ans.}$

The height of a room, is 14 ft. 10 in and the circumference 21 ft. 8 in how many square yards does it contain.

Here $14 \cdot 10 \times 21 \cdot 8 = 321 \text{ feet} \cdot 4 \text{ in} \cdot 8 \text{ p} = 357 \cdot 85$
 $8 \text{ feet} \cdot 5 \text{ in} \cdot 4 \text{ p} = \text{Ans. required?}$

Suppose a room that was to be painted at 8d. per square yard, measured as follows: The height is $11 \cdot 7$ in. The girth for cornices, $7 \cdot 4$ in. The door, $7 \cdot 6$ in by $3 \cdot 9$ in; five windows shutters, each $6 \cdot 8$ in by $3 \cdot 4$ in. The breaks in the windows, $1 \cdot 4$ in deep, and $8 \cdot 7$ high; the chimney $6 \cdot 9$ by $5 \cdot 6$ as close to the height of the room $3 \cdot 2$ f. deep, and $4 \cdot 4$ f. in front, where there is shelving, at $22 \cdot 6$ in by $10 \cdot 7$ - the shutters, doors, and shelves being all coloured on both sides: what will the whole come to?

Here $7 \cdot 4 \cdot 10 \text{ in} \times 11 \cdot 7 = 890 \cdot 1 \cdot 10 = \text{room. And } 3 \cdot 6 \times 3 \cdot 6$
 $+ 4 \cdot 9^2 + 11 \cdot 9^2 = 140 \cdot 3 + 6 \cdot 10 \cdot 3 = 147 \cdot 1 \cdot 3 = \text{Close. Also } 6 \cdot 8 \times$
 $6 \cdot 8 \times 3 \cdot 4 \times 5 = 22 \cdot 2 \cdot 8 \times 5 = 110 \cdot 11 \cdot 4 \cdot \text{And } 1 \cdot 2 \times 8 \times 5$
 $= 46 \cdot 8 = \text{breaks. Again } 22 \cdot 6 \times 10 \times 2 = 37 \cdot 6 = \text{shelves. And}$
 $6 \cdot 9 \times 5 \cdot 0 = 33 \cdot 9 = \text{shut. Whence } 890 \cdot 1 \cdot 10 + 221 \cdot 10 + 147 \cdot 1 \cdot 3$
 $+ 46 \cdot 8 + 37 \cdot 6 + 33 \cdot 9 = 907 \cdot 8 = 4 \cdot 15 \cdot 2 \cdot 2 = \text{Ans. required?}$

Of Paviors' Work.

Paviors' work is done by the square yard, and the content is found by multiplying the length, by the breadth.

Or, if the dimensions be taken in feet, and the area be found in the same measure, the result, being divided by 9, will give the number of square yards required.

Examples.

What will the paving a rectangular court yard come to at 3s. 2d. per yard, supposing the length to be 27 feet 10 inches, and the breadth 14 feet 9 inches.

$$\text{Here } 27 \overset{\text{in}}{10} \times 14 \overset{\text{in}}{9} = 410 \cdot 6 \cdot 6 = 45 \cdot 5 \cdot 6 \cdot 6$$

$$\text{And } 45 \cdot 5 \cdot 6 \cdot 6 \text{ at } 3 \text{ s. } 2 \text{ d. per yd.} = 77 \cdot 4 \cdot 4 \text{ p } 2 = \text{Ans}^r -$$

A rectangular court yard is 42 feet 9 inches long and
 68 feet 6 inches in depth, and a footway goes quite
 through it of 5 feet 6 inches in breadth; the foot
 way is laid with stone at 3s. 6d per yard and the
 rest at 3s. per yard with pebbles: what will the
 whole come to?

Here 42.75×5.5 at $3.6 = 26.1.1.6 = 4.15.3\frac{3}{4}$
 = footway.

Incl $42.75 \times 68.5 - 5.5$ at $3. = 299.2.3$ at
 $3. = 44.17.6\frac{3}{4} =$ paved part.

Whence $44.17.6\frac{3}{4} + 4.15.3\frac{3}{4} = 49.12.10 =$
 Answer required.

9. Glaziers' Work

Glaziers, take their dimensions in feet, inches, and parts, and estimate their work by the square foot.

In taking the length and breadth, of a window, the cross-bars between the panes are included.

Windows of every form are measured as if they were squares, and the greatest length and breadth, are constantly to be taken, on account of the waste attending the cutting.

Examples.

If a pane of glass be 2 feet, 8 inches, and 3 quarters,
long, and 1 foot 4 inches 1 quarter, broad: how many
feet does it contain?

Here $(2.729 (= 2^{\text{ft}} 8\frac{3}{4}^{\text{in}})) \times 1.354 (= 1^{\text{ft}} 4\frac{1}{4}^{\text{in}}) \times 12 = 3.695066$
 $\times 12 = 44.340792$ feet - Ans? $3^{\text{ft}} 8^{\text{in}} =$ quantity required.

What will the glazing of a triangular stay up, if
come to at 12d. per foot, supposing the base to be 12
feet, 6 inches, and the perpendicular height, 16 feet
9 inches.

Here $16.75 (= 16^{\text{ft}} 9^{\text{in}}) \times 12^{\text{ft}} 6^{\text{in}} \text{ or } 12.5 \times 10d = 10d$
per foot square = $209.375 \times 10 = \underline{2093.75} \div 2$ Ans?
Or $(\underline{2093.75} \div 12) \times 20 = \underline{174^{\text{ft}} 3\frac{3}{4}^{\text{in}}}$ Or $174^{\text{ft}} 3\frac{3}{4}^{\text{in}}$
 $\div 20 \div 2 = \underline{8^{\text{ft}} 14^{\text{in}} 5\frac{3}{4}^{\text{in}}} = \underline{4^{\text{ft}} 7^{\text{ft}} 2\frac{3}{4}^{\text{in}}} =$ Ans^r required

There is a house with 3 tier of windows, three in a tier; the height of those in the lower tier, being 7 feet 9 inches; of those in the middle 6 feet 6 inches, and of those in the upper tier 5 feet 3 1/4 inches and having also a circular window, above the window door, the greatest height of which, is, 1 foot 10 1/2 inches, and the common breadth, of all the windows 3 feet 9 inches what will they bring, come to at 13 1/2 d per foot.

$$\text{Here 1st tier. } 7 \text{ ft } 9 \text{ in} \times 3 \text{ ft } 9 \text{ in} \times 3 = 29 \text{ ft } 3 \text{ in } 6 \times 3 \\ 87 \text{ ft } 10 \text{ in } 6 = 1 \text{st tier}$$

$$\text{And } 6 \text{ ft } 6 \text{ in} \times 3 \text{ ft } 9 \text{ in} \times 3 = 24 \text{ ft } 4 \text{ in } 6 \times 3 = 73 \text{ ft } 1 \text{ in } 6 = \\ 2 \text{nd tier}$$

$$\text{Again } 5 \text{ ft } 3 \text{ in } 3 \text{ in} \times 3 \text{ ft } 9 \text{ in} \times 3 = 49 \text{ ft } 9 \text{ in } 2 \text{ in } 3 \text{ in} \times 3 = \\ 59 \text{ ft } 3 \text{ in } 6 \text{ in } 9 \text{ in} = 3 \text{rd tier.}$$

$$\text{Also } 1 \text{ ft } 10 \text{ in } 6 \text{ in} \times 3 \text{ ft } 9 \text{ in} = 7 \text{ ft } 0 \text{ in } 4 \text{ in } 6 \text{ in} = \text{window over door.}$$

$$\text{Where } 87 \text{ ft } 10 \text{ in } 6 \text{ in} + 73 \text{ ft } 1 \text{ in } 6 \text{ in} + 59 \text{ ft } 3 \text{ in } 6 \text{ in } 9 \text{ in} + 7 \text{ ft } 0 \text{ in } 4 \text{ in } 6 \text{ in} \\ \text{at } 13 \text{ 1/2 d per foot} = 227 \text{ ft } 3 \text{ 1/4 in } 11 \text{ in } 3 \text{ in } 13 \text{ 1/2 d} = 12 \text{ s } 15 \text{ d } 10 \text{ 1/4} = \text{ans.}$$

There is a house with 3 tier of windows, three in a tier: the height of the first tier is 7 feet 10 inches; of the second 6 feet 0 inches; of the third 5 feet 4 inches, and the breadth of each 3 feet 11 inches:

what will the glazing come to at 14d per foot?

$$\text{Here } 7 \text{ ft } 10 \text{ in} \times 3 \text{ ft } 11 \text{ in} \times 3 = 30 \text{ ft } 0 \text{ in} \times 3 = 92 \text{ ft } 0 \text{ in} \times 3 = 1^{\text{st}} \text{ tier.}$$

$$\text{And } 6 \text{ ft } 0 \text{ in} \times 3 \text{ ft } 11 \text{ in} \times 3 = 26 \text{ ft } 1 \text{ in} \times 3 = 78 \text{ ft } 4 \text{ in} \times 3 = 2^{\text{nd}} \text{ tier}$$

$$\text{Also } 5 \text{ ft } 4 \text{ in} \times 3 \text{ ft } 11 \text{ in} \times 3 = 21 \text{ ft } 16 \text{ in} \times 3 = 65 \text{ ft } 0 \text{ in} \times 3 = 3^{\text{rd}} \text{ tier}$$

$$\text{Hence } 92 \text{ ft } 0 \text{ in} \times 3 + 78 \text{ ft } 4 \text{ in} \times 3 + 65 \text{ ft } 0 \text{ in} \times 3 \text{ at } 1^{\text{d}} 2 =$$

$$\text{£ } 14 \text{ } 13 \text{ } 4 \frac{3}{4} = \text{Ans. required.}$$

Of Vaulted, and Arched Roofs.

Arched roofs are either vaults, domes, saloons, or
groins.

Vaulted roofs, are formed by arches springing from
the opposite walls, and meeting in a line, at the top.

Some are made of arches springing from a circular
or polygonal base, and meeting in a point, at the top.

Saloons are formed by arches, connecting the side walls
to a flat roof, or ceiling, in the middle.

Groins are formed by the intersection of vaults with
each other.

Domes, and Saloons, rarely occur, in the practice of measuring, but vaults and groins cover the cellars, of most houses.

Vaulted roofs, are generally one of the three following sorts:

1. Circular roofs, or those the arch of which is some part, of the circumference of a circle.
2. Elliptical, or those the arch of which is some part, of the circumference of an ellipse.
3. Gothic roofs or those which are formed by two circular arcs, that meet at an angle directly over the middle of the breadth or span, of the arch.

Problem 1st

To find the solid content of circular, elliptic, or gothic vaulted roofs.

Rule.

Multiply the area of one end, by the length of the roof, and the product will be the solidity required.

Examples

What is the solid content of a semicircular vault, the span of which is 40 feet and its length 120 feet

$$\begin{aligned} \text{Here } 7054 \times 40^2 \times 120 &= 7054 \times 40 \times 40 \times 120 \\ &= \frac{7054 \times 1600}{2} \times 120 = \frac{12566400}{2} \times 120 = \\ 7539200 \text{ feet} &= 7539 \text{ ft. } 4 \text{ in. } 9 \text{ p. } 7 \frac{12}{100} \text{ths} = \\ \text{Ans? required.} \end{aligned}$$

Required the solidity of an elliptic vault, the span of which is 40 feet, height, 12 feet and length, 80 feet

$$\begin{aligned} \text{Here } 7054 \times 40 \times 80 \times 12 &= 374160 \times 80 \times 12 = \\ 25132800 \times 12 &= 3015936 = \text{Ans? required in feet} \\ \text{or } 30159 \text{ feet } 4 \text{ in. } 3 \frac{1}{2} \text{ p. } 10 \frac{12}{100} \text{ths} &= \text{Ans? is} \end{aligned}$$

What is the solid content of a gothic vault, the span of which is 40, the chord of its arc, 40 the distance of the arc from the middle of the chord 18, and the length of the vault 60.

Here ~~7054~~ $\times \left(\frac{40^2}{2} + 18^2 \right) = \frac{124 \times 24 + 18 \times 18}{3} = 1576 + 324 = 1900 = 30 = \text{area.}$

And $\frac{30 \times 40}{3} - 40 = \frac{240 - 40}{3}$ or according to rule 2nd $24^2 + 18^2 = 10 = 900 \div 10 = 50 = \text{diameter} \therefore 18 \times \frac{2}{3} (30 - 50 \times 18) = 3405$. Also, $(1 + 3405) \times 40 = 1.3405 \times 40 = 64.3440 = \text{length of the arc}$

Whence $\frac{64.3440}{2} = 32.1720 = 1544.256 = \text{sector}$
 And $\frac{30 \times 40}{2} = \frac{1240}{2} = 720 = \text{triangle}$
 Again 720 being triangle $1544.256 - 720 = 816 = \text{segment}$
 And $816 + 1544.256 \times 60 = 1352 \times 60 = 140020$
 = ans. required.

Problem 2nd

To find the concave, or convex surface, of a circular
Chapel, or Gothic, vaulted roofs.

Rule.

Multiply the length of the arch, by the length
of the vault, and the product will be the superficies
required.

Examples.

What is the ~~convex~~ concave surface, of a semicircular
vault, the span of which is 40 feet, and its length,
120.

Here $\frac{3.1416 \times 40}{2} = 125.664 = 62.832 =$ length of
the semicircle.

And $62.832 \times 120 = 7539.84 =$ ^{feet} concave surface
required.

Problem 3rd

To find the solid content of a dome; its height, and the dimensions, being known.

Rule

Multiply the area of the base, by $\frac{3}{5}$ of the height and the product will be the solidity.

Examples.

What is the solid content of a spherical dome, the diameter of the circular base, of which is 60 feet

$$7854 \times 60^2 \times 30^{\frac{2}{3}} (\text{height}) = 56548.8 = \text{solidity req.}$$

In an hexagonal spherical dome, one side of the base is 20 feet; what is the solidity.

Here $2.598076 = \text{area of a hexagon the side of which is}$
 $\times 20^2 \times 2 \div 9 = 230940088 = 10392304.$

And $10392304 \times 11.54700725 = 12000 = \text{ans.}$

Problemsth

To find the spherical content of a spherical dome.

Rule

Multiply the area of the base by 2, and the product will be the superficial content required.

Examples.

What will the painting of an hexagonal spherical dome, come to, at 1^o per yard; each side of the base being 20 feet.

Here $\{2.598076 = \text{area of a hexagon the side of which is } 1 \times 20^2\} 2 = \text{area of the base} \times 2 = 1039.230400$
 $\times 2 = 2078.4608 = \text{superficial content required}$

And 2078.4609 at 1° per yard = 11.5470044 £
at $1^{\circ} 6$ per yard = $\text{£ } 11 \text{ : } 10 \text{ : } 11$ = the expense of painting.

Problem 5th

To find the solid content, of a saloon entirely
Rule.

1. Multiply the height of the arc, As proportion,
is of the perimeter, and of the ceiling, and 3.1416
continually together, and call the product A. -
2. From the side or diameter of the room, take a like
side or diameter of the ceiling, and multiply the square of
the remainder by the proper factor, (page 1 book 5th -)
and this product again by $\frac{1}{3}$ of the height, and call
the last product B. -
3. Multiply the area of the flat ceiling by the
height of the arch, and this product added to the sum
of A and B, will give the content required. -

Example 1.

What is the solid content of a saloon, with a circular quadrant arch of 2 feet radius, springing over a rectangular room, of 20 feet long, and 16 feet wide.

Here the flat roof of the ceiling is 16 feet by 12;
And $\frac{56}{4}$ (perimeter) $\times 2$ = height $\times 2$ = (projection)
 $+ 3.1416 = 16 \times 2 \times 2 + 3.1416 = 28 \times 2 + 3.1416$
 $= 56 + 3.1416 = 175.9296 = D.$

Also $\{20 = \text{side of the room}\} - 16 = \text{side of the ceiling}$
 $+ \text{proper factor for a square} = 1.0002 \times \frac{2}{3} \text{ of the height}$
 $= 20 - 16 \times 1.0002 \times 1\frac{1}{3} = 4 \times 1.0002 \times 1\frac{1}{3} = 4 \times 4 \times$
 $1.0002 \times 1\frac{1}{3} = 16 \times 1.0002 \times 1\frac{1}{3} = 16.000 \times 1\frac{1}{3} =$
 $21.333 = E.$

And $16 \times 12 \times 2$ = height of the arch = 192 = area of
the flat ceiling $\times 2 = 384.$

Thence $16 = D + 175.9296 + (E) = 21.333 + 384 =$
 $501.2629 = \text{solid content required.}$

A circular building of 40 feet diameter, and 25 feet high, to the ceiling, is covered with a saloon, the inner radius of which is 5 feet radius; required the capacity of the room in cubic feet.

Here the flat ceiling is 40 feet radius -

$$\text{And } \frac{125.6646}{4} - \text{perimeter} \times 25 \times 5 \times 3.1416 \\ = 314169 \times 25 \times 5 \times 3.1416 = 3977 \times 3.1416 = \\ 12494.1332 = \text{SA.}$$

$$\text{Also } 30 \times 30 \times 7054 \times 5 = 32043 = \text{C.}$$

$$\text{And } 20 - 10^2 \times 1.006 \times 16 = \frac{1}{3} \times 25 = 900 \times 1.006 \\ \times 16 = 900 \times 16.44 = 30774.4652 = \text{Ans.}^2$$

Problem 6th

To find the solid content of a, vacancy, formed by a groin arch, either circular, or elliptical?

Rule.

Multiply the area of base, by the height, and the product again by .904, and it will give the solidity required.

Examples.

What is the solid content of the vacancy, formed by a circular groin, one side of its square base, being 12 feet.

Here $12 \times 12 =$ (area of the base) $\times 6 =$ height $\times .904$
 $= 144 \times 6 \times .904 = 864 \times .904 = 781.056 =$ solidity required.

What is the solid content of the cavity, formed by an elliptical groin, one side of its square base being 20 feet, and the height 6 feet?

$$\text{Here } 20 \times 20 \times 6 \times .904 = 400 \times 6 \times .904 = 2400 \times .904 = 2169.6 \text{ feet} = \text{Ans.}$$

Problem 7th

To find the concave of a circular groin.

Rule.

Multiply the area of the base by 1.1416, and the product will be the superficies required.

Examples.

What is the curve superficies of a circular groin, arch one side of its square being 12 feet?

Here $12 \times 12 \times 1.1416 = 144 (= \text{area of the base}) \times 1.1416$

$= 164.3904$ superficies required $= 164.3904$

Let $= 164 \text{ f. } 2 \text{ in } 8 \text{ p.} = \text{Ans.}^?$

What is the concave superficies of a circular groin arch, one side of its square being 9 feet.

Here $9 \times 9 \times 1.1416 = 81 \times 1.1416 = 92.4696$
 $= 92 \text{ f. } 5 \text{ in } 7 \text{ p.} = \text{Ans.}^? \text{ required.}$

What is the concave superficies of a circular grain
arch, one side of its square being 10 feet.

$$\text{Here } 10 \times 10 \times 1.1416 = 100 \times 1.1416 = 114.16 \text{ f} \\ = 114 \text{ f. in } 11 \text{ p. } \frac{1}{2} \frac{12^{\text{ths}}}{1} = \text{Ans.} -$$

Of the, Carpenter's Rule.

This instrument is commonly called Roemer's sliding rule. It consists of two pieces, of a foot in length each, which are connected together by means of a folding joint.

On one side of the rule, the whole length is divided into inches, and half quarters, for there are inches &c wanted in taking dimensions. And on this face there are also several plain scales, divided or diagonal lines into twelve parts, which are designed for measuring such dimensions as are taken in feet and inches.

On one part of the other face there is a slider and four lines A B C D, the two middle ones B and C being upon the slider.

Three of these lines A B C are double ones, because they proceed from one to 10 twice over: and the fourth line, D is a single one, proceeding from 1 to 10, and is called the unit line.

The use of the double lines, A and B is for working proportions, and finding the areas of plane figures. And the use of the unit line D, and the other double line C is for measuring solids.

When 1 at the beginning of any line is counted 1 then the 1 in the middle will be 10, and the 10 at the end 100. And when 1 at the beginning is counted 10, the 1 in the middle is 100 and the 10 at the end 1000, &c, and all the small divisions, are altered in value accordingly.

Upon the other part of this face, there is a table of the value of a load of timber, at all prices from 6s. to 2s per foot.

Some rules have likewise a line of inches, or a foot divided decimally into 10th parts; as well as tables of board measure, timber measure &c, but these will be best understood from a sight of the instrument.

The Use of the Sliding Rule Problem 1st

To find the product of two numbers, as 7 and 26.
Rule.

Set upon A, to one of the numbers (26) upon B, then against the other num. (7) on A, will be found the product (182) on B.

Note. If the third term runs beyond the end of the line, seek it on the other radius, or part of the line, and increase the product 10 times.

Problem 2nd

To divide one number by another as 510 by 12. -
Rule.

Set the divisor (12) on A, to 1 on B; then against the dividend (510) on A is the quotient $42\frac{1}{2}$ on B.

Note. If the dividend runs beyond the end of the line, diminish it 10 or 100 times to make it fall on A, and increase the quotient accordingly.

Problem 3rd

To square any number as 27.
Rule.

Set 1 upon D to 1 upon C; then against the number (27) upon D, will be found the square 729 upon C. -

If you would square 270, reckon the 1st on D to be 100; and
then the 1st upon C will be 1000, and the product
72900

Problem 1th

To extract the square root of any number, as 2268
Rule

Set 1 upon C, to 1 upon D; then against 1 (or 2268) the
number on C is 65.34 the root on D.

To value this right, you must suppose the 1 on C to
be some of these squares 1, 100, 1000, &c which is the
nearest to the given number, and then the root corres.
ponding will be the value of the 1 upon D.

Problem 5th

To find a mean proportional between any two numbers
as 27, and 50.

Rule.

Set one of the numbers (27) on C, to the same on D; then
against the other number (50) on C, will be the
mean (10.2) on D.

Note. If one part of the numbers overruns the line, take
the 100th part of it, and augment the answer 10 times.

Problem 6th

Three numbers being given to find a fourth proportion.
as; suppose 12, 20, and 57.

Rule.

Set the first number (12) on A, to the second (20) on
B; then against the third number (57) on A is the fourth
(133) on B.

Note. If one of the middle numbers runs off the line,
take the 10th part of it only, and augment the
answer 10 times.

The finding a third proportional is exactly the same
the second number being twice repeated.

Thus, suppose a third proportional was required to 21,
and 32.

Set the first 21 on B, to the second 32 on A; then
against the second 32 on B, is 48.8 on A, which is the
third proportional, required.

* The use of the rule in board and timber measure
will be shown in what follows.

If the breadth of a board be given; to find how much
in length will make a square foot.

Rule. If the board be narrow, it will be found in the table of
board measure on the rule; but if not, shut the rule & seek the breadth in
the line of board measure, running along it from that table; then over
against it on the opposite side is the length in inches required.

The side of the square piece of timber, being given; to find
how much in length will make a foot solid.

Rule. If the timber be small, it will be found in the
table of timber measure on the rule; but if not look for the
side of the square, in the line of timber measure, running along
the rule from that table, and against it in the line of
inches is the length required.

Of Timber Measure.

Problem 1.st

By the Sliding Rule.

To find the area or superficial content of a board or plank.

Rule.

Set 12 on B to the breadth in inches on A then against the length in feet on D, is the content on C in feet and fractional parts as required.

Example.

What is the value of a plank, the length of which is 8 feet 6 inches, and breadth 1 foot 3 inches throughout at $2\frac{1}{2}$ per foot.

Here 12 on B :: 15 on A :: 8 on D :: $10\frac{1}{2}$ on C.

And $10\frac{1}{2}$ at $2\frac{1}{2}$ per foot. = $2\frac{1}{4}$ = Ans. -

Problem 2nd

To find the solidity of squared, or four-sided timber.
Rule.

As the length in feet A : 22 on D : : quarter girth in inches on C : solidity on B .

Examples.

The length of a piece of timber is $20\frac{1}{2}$ feet, the breadth at the greater end is 1 foot 9 inches, and the thickness 1 foot 3 inches; and at the less end the breadth is 1 foot 6 inches and the thickness, 1 foot, what is the solidity.

Here, As 1 upon C : $19\frac{6}{12}$ upon A : : $13\frac{6}{12}$ upon B : $263\frac{1}{2}$ upon D : the mean measure.

As 16 upon C : 4 upon D : : 1.8 upon B : 16.2 upon D : the side of the mean measure.

As $20\frac{1}{2}$ upon C : 12 upon D : : 16.2 upon D : $37\frac{5}{12}$ upon B :
= the answer.

Problem 3rd

To find the solidity of round or unsquared timber
Rule 1st

Multiply As the length upon C: 12 upon D ::
 $\frac{1}{4}$ girt upon D: content upon C.

Example.

A piece of timber is $9\frac{3}{4}$ feet long, and the quarter
girt 39 inches: what is the solidity?

As $9\frac{3}{4}$ upon C: 12 upon D :: 39 upon D: 103 upon C =
the content.

Rule 2nd

As twice the length upon C: 12 upon D :: $\frac{1}{5}$ of the
girt upon D: content upon C

Example

A piece of timber is $9\frac{3}{4}$ feet long, and $\frac{1}{5}$ of the girt is
2.6 feet: what is the solidity?

As 19.5 on C: 12 on D :: 31.5 in. on D: 132, = content upon C, = Ans.

Burrow's rule

Rule 3rd -

Multiply the square of the circumference, by the length and take $\frac{1}{3}$ of the product. From this last number, subtract $\frac{1}{3}$ of itself, and the remainder will be the answer. The following problems with shew, the artifices that may be used, in measuring timber according to the false method now practised, and the absolute necessity there is of abolishing it.

Problem 4th -

To find, where a tree, must be cut, so that the two parts measured separately, shall produce a greater solidity than that of the whole tree, or any other two parts of it. Rule. Cut it exactly, in the middle, or at $\frac{1}{2}$ of the length, and the two parts, will, measure the most possible.

Example

Supposing a tree girt, $1\frac{1}{2}$ feet at the greater end 2 feet
at the less, and 8 feet in the middle, and that the length
is 32 feet

Then, by the common method, the whole tree measures
only 128 feet.

But, when cut through the middle, the greater part
measures 121 feet, and the less part 25.

And the sum of these two parts is 146 feet which exceeds
the whole by 18 feet, and is the most that it can be
made to measure, by cutting it into two parts

Problem 5th

To find where a tree must be cut, so that the part next
the greater end, may measure the most possible.

Rule. Cut it where the girt is $\frac{1}{3}$ of the greatest girt
and the greater end will measure the most possible

Example.

Taking here the same example as before, we shall have
 $12: 5^{\frac{3}{4}} : 7\frac{1}{2} =$ length to be cut off, $24\frac{2}{3} =$ length of the remain-
ing part, and $4^{\frac{2}{3}} =$ girth at the section.

But the content of the whole tree is only 120 feet, and
the content of the greater part $135\frac{5}{8}$, which exceed by
 $15\frac{1}{8}$ and, is the greatest possible.

Problem 3rd -

To cut a tree, so that the part next the greater end, may
measure exactly the same as the whole tree.

Rule 1. Call the sum of the girths C , and their differ-
ence M .

2. Multiply M by the sum of C , and 4 C and from
the square root, of the product, take the difference between
 M , and $2C$.

3. Then as $2M$ is to this remainder, so is the whole length, of the
tree, to the length to be cut off the smaller end.

Of Specific Gravity.

The specific gravities of bodies, are their relative weight, contained under the same given magnitude, as a cubic foot, a cubic inch, &c.

The specific gravities of several sorts of bodies are expressed, by the numbers annexed to their names, in the following table.

Note. As a cubic foot of water, weighs just 1000 ouncesavoirdupois the numbers, in this table express, not only the specific gravities, of the several bodies, but also the weight of a cubic foot of each, inavoirdupois ounces; and hence, by proportion, the weight of any other quantity, or the quantity on any other weight, may be exactly.

Table of the specific gravities of bodies.

Fine Gold	19,640 Brick	2,000
Standard Gold	18,888 Light earth	1,984
Duck silver	14,000 Solid gunpowder	1,745
Lead	11,325 Sand	1,520
Fine silver	11,091 Pitch	1,150
Standard silver	10,535 Dry boxwood	1,030
Copper	9,000 Seawater	1,030
Gun metal	8,784 Common water	1,000
Cast Brass	8,000 Gunpowder shaken	922
Steel	7,850 Dry ash	800
Iron	7,645 Dry Plum	600
Cast Iron	7,425 Dry Fir	550
Tin	7,320 Cork	240
Marble	2,700 Air	1 $\frac{1}{4}$
Common Stone	2,520 Dry oak	925
Loom	2,160 Dry Maple	755

Problem 1st.

To find the magnitude of a body, from its weight
being given

Rule.

As the Tabular specific gravity of the body, is to its
weight, in avoirdupois ounces, So is one cubic foot, or 1728,
cubic inches, to its content, in feet or inches respectively

Examples.

Required the content of an irregular block of common
stone, which weighs 112 or 112 lbs.

Here 112 lbs. $\times 16 = 1792$ ounces. And As, 2520 = (Tab. grav)
 $1792 :: 1728 : 1228\frac{4}{5}$ cubic inches = the Ans^r.

How many cubic inches of gun powder, are there in a
pound weight.

Here 16 ounces = 1 lb. As 1745 : 16 :: 1728 : 29.9071
cubic inches = answer.

How many cubic inches of gunpowder, are there in one pound weight.

Here $1745 : 16 :: 1728 : 30$ nearly = Ans.

How many cubic feet are there in a ton weight, of dry oak.
Here $25 : 35840 =$ answer in tons $1728 : 38\frac{1}{2}$ feet = Ans.

Problem 2nd

To find the weight of a body, from its magnitude, being given.

Rule.

As one cubic foot or 1728 cubic inches, is to the content of the body,

So is its tabular specific gravity, to the weight of the body.

Examples.

What is the weight of a block of dry oak, which measures 10 ft. in length, 3 ft. in breadth and $2\frac{1}{2}$ ft. deep.

Here $2.5 \times 10 \times 3 = 75 = \text{solidity}$. And As $1:75$
 $\therefore 925:2335 \text{ lbs. } 15 \text{ oz} = \text{Answer}$.

What is the weight of a pint of gunpowder, cu.
measures.

Here 35.175 inches being to a pint: As $1720:35.175::$
 $1922:18.8 \text{ oz} = 19 \text{ nearly} = \text{Ans.}$

Problem 3rd

To find the specific gravity of a body.
Rule.

Case 1. When the body is heavier than water, weigh
it both in water and out of water, and the difference
will be the weight lost in the water.

Then, as the weight lost in water, is to the whole
weight,

So is the specific gravity of water, to the specific
gravity of the body.

Example.

A piece of stone weighed in air 10 pounds, but in water only $6\frac{3}{4}$ lbs. Required its specific gravity.

Here $10 - 6\frac{3}{4} = 3\frac{1}{4}$. As $3\frac{1}{4} : 10 :: 1000 : 1340 :: 1000 : 3077$
= Answer.

Case 2. When the body is lighter than water, so that it will not quite sink; affix to it another body, heavier than water, so that the mass compounded of the two may sink together,

Weigh the heavier body, and the compound mass separately, both in water, and out of it, and find how much each loses in water, by subtracting its weight in water from its weight in air.

Then as the difference in these remainders, is to the weight of the light body in air,

So is the specific gravity of water, to the specific gravity of the body.

Example.

Suppose a piece of Iron weighs in air 15 lb and that a piece of copper which weighs 18 lb in air, and 16 lb in water, be affixed to it, and the compound is 6 lb in water; required the specific gravities of the elements.

Here $18 - 16 \times 33 - 6 = 25 \therefore 25 : 15 :: 100 : 600 = \text{Ans.}$

Problem 4th

To find the quantities of 2 ingredients in a given compound.

Rule.

Take the difference of every pair of the three specific gravities viz. of the compound, and each ingredient, and multiply the difference of every two, by the third number of figures.

Then as the greatest product, is to the whole weight of the compound,

So is each of the other products, to the weights of the two ingredients.

Example.

A composition of 112 lb, being made of tin and copper the specific gravity of which is found to be 8784; required the quantity of each ingredient; the specific gravity of tin being 7320, and of copper 9000.

Then $9000 - 7320 \times 8784 : 9000 - 8784 \times 7320 ::$
 $8784 - 7320 \times 900$. Or $As\ 14757120 : 112 :: 13176000$
 $: 100$. Ans^r. Or 100 lb of copper and 12 lb of tin in the
composition

Miscellaneous Questions.

Seven men bought a grinding stone of 40 inches in diameter, each paying 7 parts of the expense; what part of the diameter must each grind down for his share?

Here the 1st 4.4508, 2d. 4.8400, 3d. 5.3535, 4th. 6.0765, 5th. 7.2079, 6th 9.3935, and the seventh 22.6770. Ans?

In the middle of a meadow well stored with grass.

I took just an acre to tether my ass;

How long must the chord be that feeding a round,

The margin of grass less or more than an acre of ground.

$$\begin{array}{r} 4840 \div 2 = 2420 \\ 7034 \div 2 = 3517 \end{array} \quad \begin{array}{r} 2420 - 3517 = -1097 \\ 7034 - 1097 = 5937 \end{array} \quad \begin{array}{r} 5937 \div 2 = 2968.5 \end{array}$$

Or 39 yds. of 4 in. 10 p. Ans?

3
The answer I have given to him is to sit;
Those Tongues ran a great deal too fast for his wit;
He talked of his art with abundance of mettle;
So I ask'd him to make me a flat bottom'd kettle;
Let the top and the bottom diameter be,
In such such proportion as five is to three;
Twelve inches the depth I propos'd, and no more;
And to hold in a gallon seven less than a score.
He promis'd to do it, and straight to work went;
But when he had done it he found it to scant.
He alter'd it then but too big he had made;
For though he had right the diameters said it;
Thus making it often too big and too little,
Theinker at last had quite spoil'd his kettle.
But he swears he will bring his said promise to pass,
Or else that he'll spoil every one of his brass.
Now to keep him from ruin, I pray find him out,
The diameter length for he'll never do it I doubt.
Here the bottom diameter is 14.4 in and top one 24.2 =
14 in. 4 p. 9. 12ths. 24 in 2 p. 4 12ths = Ans. required.

7 Men bought a Home 60 for dinner with party / dinner must be paid for his share

$$60 \text{ --- } \sqrt{60^2} \text{ --- } 60^2 \div 7$$

$$\text{--- } 60 \text{ --- } \sqrt{3600} \text{ --- } 3600 \div 7$$

$$\text{--- } 60 \text{ --- } \sqrt{3600} \text{ --- } 514.28572 \text{ nearly}$$

$$\text{--- } 60 \text{ --- } \sqrt{3085.71428} \text{ nearly}$$

$$\text{--- } 60 \text{ --- } 55.5492 \text{ --- } 4.4508 \text{ 1}^{\text{st}} \text{ mans share}$$

again $55.5492 \text{ --- } \sqrt{55.5492^2} \text{ --- } 55.5492^2 \div 6$

$$\text{--- } 55.5492 \text{ --- } \sqrt{3085.71552} \text{ --- } 3085.71552 \div 6$$

$$\text{--- } 55.5492 \text{ --- } \sqrt{3085.71552} \text{ --- } 504.28559667$$

$$\text{--- } 55.5492 \text{ --- } \sqrt{2571.42793333} \text{ ---}$$

$$\text{--- } 55.5492 \text{ --- } 30.7092 \text{ --- } 4.84 \text{ 2}^{\text{nd}} \text{ mans share}$$

again $30.7092 \text{ --- } \sqrt{30.7092^2} \text{ --- } 30.7092^2 \div 5$

$$\text{--- } 30.7092 \text{ --- } \sqrt{2571.42288} \text{ --- } 2571.42288 \div 5$$

$$\text{--- } 30.7092 \text{ --- } \sqrt{2571.42288} \text{ --- } 514.284576$$

$$\text{--- } 30.7092 \text{ --- } \sqrt{2057.138504} \text{ ---}$$

$$\text{--- } 30.7092 \text{ --- } 45.55563 \text{ --- } 5.5555 \text{ 3}^{\text{rd}} \text{ mans share}$$

again $45.55563 \text{ --- } \sqrt{45.55563^2} \text{ --- } 45.55563^2 \div 4$

$$\text{--- } 45.55563 \text{ --- } \sqrt{2057.13306} \text{ --- } 2057.13306 \div 4$$

$$\text{--- } 45.55563 \text{ --- } \sqrt{2057.13306} \text{ --- } 514.283265$$

$$\text{--- } 45.55563 \text{ --- } \sqrt{1542.849795} \text{ ---}$$

$$\text{--- } 45.55563 \text{ --- } 89.2791 \text{ --- } 6.0765 \text{ 4}^{\text{th}} \text{ mans share}$$

again $89.2791 \text{ --- } \sqrt{89.2791^2} \text{ --- } 89.2791^2 \div 3$

$$\text{--- } 89.2791 \text{ --- } \sqrt{1542.836} \text{ --- } 1542.836 \div 3$$

$$\text{--- } 89.2791 \text{ --- } \sqrt{1542.836} \text{ --- } 514.27866$$

$$\text{--- } 89.2791 \text{ --- } \sqrt{10285.373} \text{ ---}$$

$$\text{--- } 89.2791 \text{ --- } 82.0712 \text{ --- } 7.2079 \text{ nearly 5}^{\text{th}} \text{ mans share}$$

$$\text{--- } 82.0712 \text{ --- } \sqrt{82.0712^2} \text{ --- } 82.0712^2 \div 2$$

$$\text{--- } 82.0712 \text{ --- } \sqrt{1028.6} \text{ --- } 1028.6 \div 2$$

$$\text{--- } 82.0712 \text{ --- } \sqrt{1028.6} \text{ --- } 514.3$$

$$\text{--- } 82.072 \text{ --- } \sqrt{514.3} \text{ ---}$$

$$\text{--- } 82.072 \text{ --- } 22.6777 \text{ --- } 9.3535 \text{ 6}^{\text{th}} \text{ mans share}$$

again $22.6778 \text{ --- } 0 \text{ --- } 22.6778 \text{ for the 7}^{\text{th}} \text{ mans share}$

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